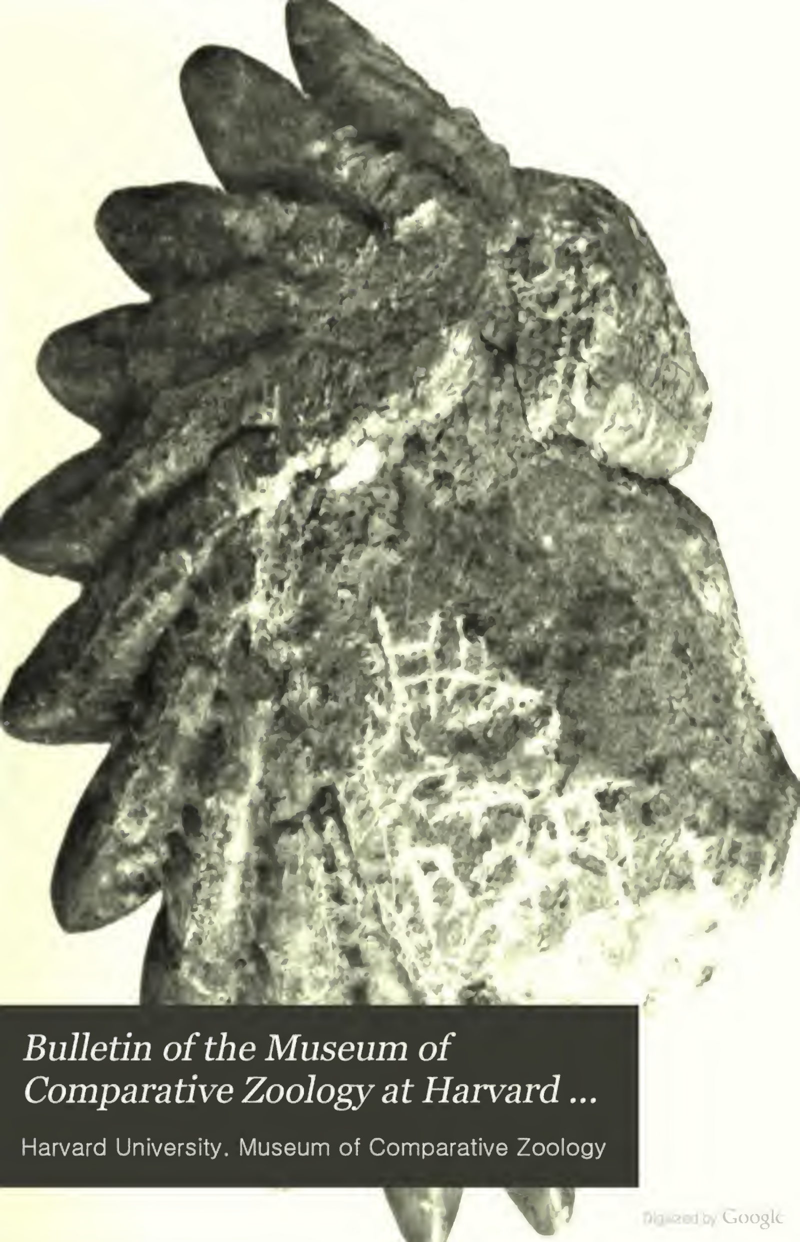

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AT HARVARD COLLEGE.

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SOME REPTILES AND BATRACHIANS FROM AUSTRALASIA.

By Samuel Garman.

With Two Plates.

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No. 1. — *Some Reptiles and Batrachians from Australasia.*
By Samuel Garman.

Many of these specimens were taken, at various localities, by members of Mr. Alexander Agassiz's Expeditions to the Great Barrier Reef of Australia and to the Fiji and Samoan Islands, and a large number were donated by Mr. E. A. C. Olive, who had made Cooktown, Queensland, the point of departure for his collecting excursions. Among them there are certain types that are particularly interesting, since they are closely allied to others, already described, from the southern and the western parts of Australia, and yet are sufficiently distinct to demand descriptions and names, on account of importance in considerations of distribution and derivation. While some of them appear to be new, all of them have close affinities with species more or less widely distributed in the region. In the collection there are thirty-four species, and these pertain to twenty-two genera of fourteen families.

Gymnodactylus pelagicus Boul.

Heteronota pelagica Gir.

Individuals taken on the Barrier Reefs, by the members of the expedition, and at Cooktown, by Mr. Olive, agree well with the original description drawn from those taken on the Fiji and Navigator Islands. The rows of tubercles vary in number from sixteen to eighteen; the small scales of the dorsum have three or more keels; and on some the labials number eight upper and six lower.

Gymnodactylus Olivii, sp. nov.

Plate 1, Fig. 1-1d.

Head large, depressed, widest across the space between the ears and the eyes, three-fourths as wide as long, tapering from the postocular region to the snout. Snout nearly one-third longer than the space between the orbits and the ear, blunt. Forehead slightly concave. Ear opening small, subtriangular. Body moderately depressed; limbs moderate; digits depressed at the base, compressed in the distal portion, with broad transverse plates under the basal joint;

tail one-seventh longer than the body; slender, round, tapering regularly. Head scales granular, crown from the eyes backward with numerous minute tubercular scales. Rostral large, wider than high, joined on the upper edge by two nasals and a smaller subquadrangular internasal. Nostril edged by the rostral, nasal, a small scale joining the latter, four or five granules, and the first labial. Labials thirteen; lower labials eleven; mental large, pentagonal, wedged between two large chin shields, which latter meet for a considerable distance behind the angle of the mental. Smaller chin shields decrease in size backward, from the anterior, at the lower edges of the labials. Throat with granules. Back covered with granules, in which there are twenty-four longitudinal series of small tubercular scales, of which those near the thighs and tail are more elongate, and rise in a low blunt point or short depressed keel. Abdominal scales larger, flat, smooth, imbricate, rounded on the free edges, in twenty-eight longitudinal rows. Upper caudal scales similar to those of the hinder portion of the back; scales of the lower surfaces of the tail, flat, smooth, irregular in shape and in width, many of them reaching across the entire lower side.

Light grayish brown with transverse bands of darker, white below. Top of head light, with small streaks and spots of brown; a dark band with darker edges from the end of the snout through the eye above the ear behind the occiput crossing the nape; a similar band across the space between the shoulders, three across the body between the arms and the legs, and one across the space between the hips. Similar bands cross the tail, where they are darker, and the difference in depth of color in edges and median portions disappears. Name in honor of Mr. E. A. C. Olive.

This form differs from *G. pelagicus* in tubercles, chin shields, abdominal scales and markings.

Queensland, near Cooktown; Mr. Olive.

Phyllurus cornutus Ogil.

P. lichenosus Günt.

In Mr. Olive's collection there is a specimen rather smaller than the type and exhibiting some variation from the original description. The transverse bands of brownish on the tail completely encircle that organ, and are quite as distinct on the lower side as on the upper. On the median portion of the ventral surface of the tail the five white interspaces are much wider and whiter than the white blotches on the back of the body. The diameter of the eye is half the length of the snout. The conical tubercles on the keel at the sides of the abdomen readily distinguish this form from *P. platurus*, as also the scallops. The type of *P. cornutus* was about eight and one-fourth inches in length, that of *P. lichenosus* was about five and one-eighth, a present specimen is intermediate between the two, and, as it appears to me, conclusively establishes the identity of these species.

Œdura Mayeri, sp. nov.

Plate 2, Fig. 2–2c.

Form similar to that of *Œ. marmorata;* depressed, elongate, transversely banded. Head depressed, large, long, subtriangular, pointed in front, widest between the ears and the eyes, concave on the forehead; snout as long as the distance from eye to ear, blunted at the end, one and one-half times the length of the orbit. Ear opening oblique, two-thirds as wide as the eye. Limbs medium, depressed, in large specimens as broad as the apical expansions, narrower in the young. Apical expansions broader than long, with a pair of rounded plates. Four pairs and a number of undivided infradigital plates. Head plates small, flat, smooth, nearly uniform in size, irregularly polygonal in shapes, larger between the eye and the nasal plates. Rostral large, eight sided, about twice as wide as high, with a slight median cleft above. Nostril surrounded by six plates, rostral, first labial and four nasals; upper two nasals large, anterior largest and meeting the opposite nasal behind the rostral. Eleven labials; nine lower labials. Mental subtriangular, truncated and in contact with a heptagonal submental which separates the first pair of lower labials; enlarged submentals in contact with all the lower labials, their sizes decreasing regularly to the small subgulars. Back, sides, and belly covered with small hexagonal to subcircular smooth scales larger than those of the head; scales of the belly larger; caudal scales broader than long, subhexagonal. Femoral pores twenty. Tail long, five sixths as long as the body, slightly depressed, thickened anteriorly, tapering backward to a point, not as wide as the body. A single rounded and flattened tubercular scale at each side of the base of the tail.

Adults are brown to light grayish brown, with a whitish band from the end of the snout below the eye across the ear and around the occiput on the nape, top of head lighter, four narrow transverse bands of light color across the back and six around the tail. The anterior of the bands on the body is above the shoulder, and the posterior is above the vent. The lower surfaces are whitish. On young specimens the brown is nearly black and the transverse bands are whiter and, the sides being brown, are more distinctly separated from the white of the lower surfaces.

This differs from the *Œ. marmorata* in the separated infralabials, the larger submental scales, the greater number of femoral pores and the longer more slender tail. Named in honor of Dr. A. G. Mayer.

Queensland; Dr. A. G. Mayer and Mr. E. A. C. Olive.

Gehyra oceanica Gray.

Gecco oceanicus Less.

Fijis: Samoa.

Gehyra variegata Boul.

Hemidactylus variegatus D. B.

In one case the six pores of the right side are the only ones present, a possible indication of bisexual internal conditions.

Woodworthia, gen. nov.

Gecconiform, with rounded tapering tail. Digits strongly dilated, median slightly webbed at their bases, inner and outer free; distal phalanx of inner digit raised, supporting two plates with the claw between as in Œdura, basal phalanges with broad undivided transverse lamellæ; distal phalanges of the other four digits compressed, raised, and clawed as in Hoplodactylus. Body covered above with uniform granular scales, inferiorly with larger slightly imbricated scales. Pupil vertical.

On the types four digits of each foot resemble those of Naultinus or Hoplodactylus, while the fifth digit has a distal portion more like that of Œdura, being provided with a large pad at each side of the claw below the extremity.

Generic name in honor of Dr. W. McM. Woodworth.

Woodworthia digatata, sp. nov.

Plate 1, Fig. 2-2f.

Outlines resembling those of Hemidactylus; with tail moderately long and slender. Head oval, snout narrowed, blunt, little longer than the distance between the eye and the ear; ear opening large, narrow, oblique; eye large, prominent. Body and limbs moderate, feet large. Digits broad, outer and inner on each foot free, others united by a rudimentary web; basal dilatations large, inferiorly with a single series of transverse lamellæ; distal phalanges strong, compressed, raised and clawed on four of the digits; distal phalanx on the fifth digit differing from that of the others in being broad and bearing inferiorly a pair of large plates between which the claw rests, Plate 1, Fig. f. Twelve or thirteen lamellæ under the fourth toe. Snout covered with granules, larger between the rostral and each orbit, becoming largest and plate-like toward the rostral and the labials. Twelve labials; thirteen lower labials. Rostral more than twice as broad as high, cleft at the upper edge. Nostril pierced between the rostral, first labial, and four nasals. Three scales across the snout behind the rostral between the nostrils, median smallest. Two scales behind the mental between the lower labials of the first pair. Two small scales behind each of the first pair of lower labials, and one or two behind each of the second pair. Behind those mentioned the scales gradually decrease in size to the granules. On the back and the limbs the granules are uniform and very small; on the lower surfaces they are larger and subimbricate; on the tail they are broader and arranged in rings. There is a small tubercular scale behind each thigh at each side of the base of the tail, and a group of larger ones behind the vent. Neither femoral nor preanal pores are discovered on these specimens.

Light reddish brown, with five irregular transverse ashy blotches across the body and about eight across the tail. A light area from the supraorbitals backward, lighter specks, spots, cloudings or mottlings on face, flanks and limbs. On some the ashy blotches are indistinct or absent, and the spaces between them appear as darker edged transverse bands.

"New Zealand; Mr. Edwards."

Lepidodactylus lugubris Fitz.

Platydactylus lugubris D. B.

One specimen from Suva has two tails, a smaller more perfect tail rising on the top of a much larger stump, above the anterior caudal vertebræ, some distance forward of the end, instead of at the extremity, as in the more common reproductions.

Suva and Wailagilala, Fiji Islands, and Upolu, Samoa; Dr. Woodworth.

Delma reticulata, sp. nov.

Plate 2, Fig. 1-1 f.

Body elongate, slender; tail much longer; head long, less than one-eighth of the length from snout to vent, subquadrangular in transsection, pointed, tapering from midway between the eyes and the ears, bluntly rounded at the end of the snout; jaws nearly equal. Snout hardly as long as the space between the orbit and the ear. Earopening oblique, less than half as long as the eye. Rudimentary limbs two-thirds as long as the snout, three-fourths as wide as long, with five scales, $2 + 2 + 1$. Rostral scale subtriangular, nearly twice as wide as high; a pair of frontonasals; nostril pierced between the frontonasal, the nasal, and the first labial; labials five or six, third elongate, below the orbit and separated from it by a series of small scales, second separated from prefrontal and loreal by two small scales; prefrontals wide, wider than long; frontal large, longer than wide, octagonal; postfrontal not so large as the frontal, heptagonal, in contact with two large supraorbital shields, the outer edges of which rest against three or four smaller supraciliaries; small scales separate the loreal and the postorbitals from the eye; parietals larger than the postfrontal, hexagonal; post parietals small, separated on the median line by two lozenge-shaped cells; mental shield larger than the rostral, with three angles; lower labials four or five, anterior of opposite sides in contact behind the mental, second largest and meeting a smaller scale on the median line, third long and narrow and in contact with a larger plate at the lower edge. Thirteen or fourteen small gular scales between the chin and the enlarged ventral scutes. Scales smooth, in fourteen rows around the body, and in twenty rows around the middle of the neck. Fifty-two pairs of ventral scutes from gulars to vent; each scute twice the size of the dorsal scales, or larger, less than twice as wide as long. Preanal scales three, outer two larger, middle one triangular acute-angled backward. Scutes below the tail in a single series for a considerable distance, thence smaller and irregularly placed. Tail less than twice as long as head and body.

Back reddish brown, belly whitish, chin and throat white. The white of the throat extends upward in pointed areas on the sides of the head. Top of head with three transverse blotches of black narrowly separated by two streaks of white; broadest band across the space between the ears, a narrower band immediately back of the ears on the nape, and the third across the interorbital space. Snout dark in the upper portion, with an indistinct transverse line of lighter color across the forward end of the frontal. The darker color on the first and second labials encroaches on the lower labials, as also is the case with the black band through the eye. The edges of the scales are little darker, forming reticulations.

Queensland; Mr. Olive.

Diporophora bilineata GRAY.

One specimen of a light reddish brown color, with numerous transverse bands of brownish on the upper side of the tail, and with darker bands of brownish at the sides of the neck and along the flanks.

Queensland.

Chlamydosaurus Kingi GRAY.

On several of the smaller specimens the frill is very short, occupying but two-sevenths of the length from the end of the snout to the end of the frill.

Queensland; Mr. Olive.

Brachylophus fasciatus WAGL.

Iguana fasciata BRONGN.

From Levuka, Ovalau Island, and Suva, Viti Levu, of the Fiji Islands. The specimen from Levuka has five enlarged sharp-edged scales directed down below the proximal joint of the third toe of the hind foot; on the second and the third toes the enlarged scales are smaller and fewer in number, three to four. It has sixteen femoral pores on each side. On an individual from Suva there are six enlarged scales below the third toe, the scales below the first and second toes are similar but smaller, and there are nineteen femoral pores on each side. A note by the captor remarks: "In life the colors change rapidly from green to green with blue-grey bands," which raises the question whether it is right to state that the male is banded and the female uniform in color. In one case there are fourteen femoral pores on one side and fifteen on the other; in another there are twelve on one side and fourteen on the other.

Lygosoma tenue Boul.

Tiliqua tenuis Gray.

Scales in twenty-eight rows around the body.
Cooktown; Mr. Olive.

Lygosoma noctua P. D.

Scincus noctua Less.

Upolu, Samoa; Dr. Woodworth.

Lygosoma fuscum Boul.

Heteropus fuscus D. B.

The present variety was collected by Mr. Olive near Cooktown. It has a dark band from the snout through the eye to the shoulders, which is white-edged and longer in the young. On some large specimens the line between the eye and shoulder is very black, and is broken by narrow streaks of white into several blotches. In cases there are white specks scattered over the flanks. Commonly the tail is lighter in color than the body and more red; it is thick at the base and tapers somewhat abruptly. Another variety taken at "Cairns" by Dr. A. G. Mayer is dark olive, and has thirty-four rows of scales around the body, instead of thirty-six as in the first form.

Lygosoma æratum, sp. nov.

Lacertiform; the distance from the end of the snout to the arm is one-third of the length from snout to vent. Head moderate, rather pointed at the snout, subquadrangular in transsection; snout short, one and one-half times the length of the eye, blunt. Lower eyelid with a large undivided transparent disk, larger than the earopening. Nostril pierced in a single nasal. Frontonasal wider than long, broadly in contact with the rostral, narrowly in contact with the frontal. No supranasal. Frontal in contact with two supraorbitals, shorter than the frontoparietal. Prefrontals not in contact, larger than the interparietal. Interparietal small, subtriangular, edges convex. Parietals forming a suture. A pair of broad nuchals. A large temporal shield in contact with each parietal. Lower labials six. Anterior submental very broad, with a blunt angle in front, followed by a pair of large shields forming a suture behind it, this pair followed by another pair separated by a small shield, and these again by a third pair separated by three scales. Labials five or six, eye over the third or the fourth, which is much elongated. Supraorbitals four, second largest, first shortest and smallest. Postnasal short, oblique. Loreal comparatively large. Earopening smaller than the eye, elongate, hidden by sharp lobules from the upper side and from the lower. Scales smooth, in twenty-two rows around the body, largest on the back, smallest on the flank. In six or seven of the anterior series the subcaudal scales are small, behind these there is a median series of much broader ones. Limbs moderate, hardly meeting when adpressed; anterior with four digits, posterior with five. Fourth toe with about eighteen subdigital lamellæ. Tail one and three-fifths times the length of head and body.

Light bronzed olive on back and sides, lustrous whitish to light olivaceous below; each scale of back and sides with several darker streaks, resembling keels in effect, spreading into larger blotches on the tail; lighter patches on scales of the sides of the tail. Frecklings or small spots on lips, sides of throat and belly, and below the pelvic region and the tail. Limbs freckled with white.

Near Cooktown; Mr. Olive.

This species is allied to *L. læve* Oudem., 1894: it differs in labials, in number of rows of scales, and in the large eye-disk.

Lygosoma cyanurum Boul.

Scincus cyanurus Less.

Taviuni Island, Fiji; Dr. W. McM. Woodworth.

Lygosoma samoense Boul.

Eumeces samoensis Dum.

An individual taken on Viti Levu, Fiji, by Dr. Mayer may represent a variety of this species, since it possesses but twenty-eight rows of scales around the body, while the species is characterized by thirty or more. Other specimens collected by Dr. Woodworth on Suva have thirty-two rows.

Lygosoma atromaculatum, sp. nov.

Form similar to that of *L. isolepis* Boul. Body elongate, slightly depressed; limbs short, rather weak, not meeting by the length of the arm when adpressed; feet pentadactyl; tail one and one-half times as long as head and body, thick, round, tapering regularly. Distance from snout to fore-leg contained one and one-half times in the distance from axilla to vent. Snout short, shorter than the space between the eye and the ear. Lower eyelid scaly, transparent. Rostral hexagonal, wider than high, truncate, in contact with the frontonasal. Nostril pierced in a single nasal; no supranasal. Nasal quadrangular, in contact with the first labial; postnasal in contact with second labial; loreal in contact with second and third labials. Labials seven, fifth and sixth below the eye. Frontal one and one-half times as long as wide, broadly in contact with the frontonasal and with the anterior two pairs of supraoculars; prefrontals small; frontonasal broader than long, octagonal; frontoparietals moderate, little larger than the interparietal; parietals large, meeting behind the interparietal. Three to four pairs of nuchals, twice as wide as the shields behind them. A large shield and a much smaller one at the outer side of each parietal. Four supraorbitals, second widest. Five or six broad shields between the eye and the ear. Seven or eight supraciliaries. Mental shield large, broad, in contact with two labials and a submental. Anterior submental broader than long, in contact with five shields, followed on each side by four broad submentals, the anterior pair of which meet on the median line, the second pair are separated by a single small scale, and the third pair are separated by three scales. Earopening subelliptical, oblique, little smaller than the eye, with several hardly noticeable lobules on the anterior border. Scales smooth, in twenty-four rows around the body, dorsals larger and laterals little smaller than the ventrals; a pair of enlarged preanals. Below the tail the scales are somewhat larger than those on the upper surfaces. Rostral, nasals, first labial and mentals have in most cases the appearance of being thicker than the other head scales or of having retained the slough. Digits weak, slightly compressed; subdigital lamellæ forming a low keel, nineteen under the fourth toe.

Bronzed olive on the back, more or less lightly sprinkled with black spots which become more numerous toward and on the tail and on the limbs. Belly and lower side of tail uniform whitish. Scales of sides and lower surfaces of head and throat with black spots, those of labials and submentals most intense. Entire flanks closely spotted with small black spots; in cases the spots of sides and back become longitudinal streaks. On some individuals the back is more thickly covered with spots which are smaller forward and on the back of the head, and each labial bears a white vertical bar in the middle, the black spots being situated on the sutures and covering a portion of each scale.

Differs from *L. isolepis* Boul. and *L. elegantulum* Pet. & Dor. in the smaller number of scales.

Barrier Reef, Australia; G. B. R. Exp.: Queensland; Mr. Olive.

Ablepharus heteropus, sp. nov.

Head medium; snout short blunt, rounded, slighly projecting. Eye surrounded by granules. Rostral slightly swollen, largely in contact with the frontonasal; frontal moderate, hexagonal, in contact with frontonasal, interparietal, prefrontals, and two anterior supraoculars. Prefrontals about half as large as the frontal, not in contact. Frontoparietal large, much larger than the frontal. Interparietal distinct, small, hardly as large as a prefrontal. Four supraoculars, anterior smallest, second largest. Labials six, fourth long and below the orbit. Parietals broad, in contact behind the interparietal. Two pairs of broad nuchals. Earopening small, nearly hidden by sharp lobules from the upper and the lower edges. Scales smooth, in twenty-four rows around the body, scales of flank smallest. Preanals small. Limbs short, anterior tetradactyl, posterior pentadactyl, not meeting when adpressed. Digits short, outer on the hind foot very short. Tail longer than head and body.

Brownish olive above, lighter toward the belly, with small spots of brown below the hinder part of the abdomen, under the tail, on the limbs, along the lower edges of the flanks, and on the lips and the sides of the throat; belly, throat, and lower surface of tail white.

Near *A. Greyi* Gray, of Western and Southern Australia.

Great Barrier Reef, Queensland; G. B. R. Exp.

Ablepharus eximius Garm.

Cryptoblepharus eximius Gir.

Specimens captured by Dr. Woodworth at Nai Robu, Niue Lagoon, and Moala Island, Fijis, are of a very lustrous dark brown, with black flanks, and dark olive on the lower surfaces; the light streak above the eye is faint and extends but little farther back on the flank than the almost obsolete line below the eye. The mental shield alone of the lower surface is white.

Another locality is represented by a type which agrees with the preceding from the Fijis except in having the light color of the mental shield carried backward to about the middle of the abdomen. It was taken by Dr. Mayer in the neighborhood of Cooktown.

Ablepharus virgatus, sp. nov.

Form and size like those of *A. lineo-ocellatus* D. B. or *A. tæniopleurus* Pet.; tail as long as head and body. Head medium; snout short, blunt, rostral shield not projecting. Eye incompletely surrounded by granules. Rostral largely in contact with frontonasal, which is widely separated from the frontal. Frontal less than half as large as the frontonasal, in contact with the interparietal by a narrow suture. Interparietal three or more times the size of the frontal, fused with frontoparietals. Four supraorbitals, second largest and in contact with frontal and frontoparietal. Four supraciliaries, anterior largest, elongate. A pair of very broad nuchals followed by other pairs, not quite so broad, the widths of which gradually decrease to the neck. Four labials anterior to the subocular. Earopening small, hardly half the size of the pupil, without lobules. Scales in twenty rows around the body, smooth or with faint indications of keels, broader on back and tail, very broad below the tail. Four enlarged preanal shields. Limbs pentadactyl, hinder reaching three-fifths of the distance to the axilla.

Light yellowish brown, edge of head plates brown, with keel-like marks of brown on the median dorsal rows of scales, with a white band from the supraoculars on each side of the body, distinctly and regularly edged by a band of brown on the back and another through the eye to the base of the tail. Lower parts of flanks and upper portion of limbs and toes mottled with small spots of brown and of white. Entire ventral surface white.

Cooktown; Mr. Olive.

Ablepharus heterurus, sp. nov.

A larger species than *A. eximius*, with the head less rounded. Head moderate; snout pointed, rostral not projecting. Eye incompletely surrounded by granules, two to three small scales representing the upper eyelid. Rostral in contact with frontonasal; frontal less than half as large as the latter and widely separated from it, in contact with two supraorbitals. Four supraorbitals, second largest. Frontoparietals and interparietal fused and forming a plate about four times as large as the frontal. Frontal and frontoparietals meeting in a short transverse suture. Four supraciliaries, anterior elongate. Parietals large, meeting behind the interparietal. A pair of very large nuchals, followed by a smaller pair, back of which the width gradually decreases on the neck. No supranasals; a suture from the nostril backward in the nasal. Five labials anterior to the large subocular. Earopening small, without lobules. Scales smooth or feebly keeled, in twenty-four to twenty-six rows around the body, those of belly and flanks subequal, those of the back and tail much larger, those of the median subcaudal row largest. Tail longer than head and body.

Lustrous greenish olive; with a rather indistinct stripe of greenish white on each side of the back, irregularly edged with somewhat fused spots of brown, from supraorbital to tail; back, flanks, limbs, digits, and tail freckled with small spots of brown and of white. Ventral surfaces greenish white to greenish yellow, more green under chin and throat. Mental and rostral white. The distal one-third or two-fifths of the tail is colorless in alcoholic specimens. Probably it was red or yellow in life; the contrast with the darker colors of the anterior part of the tail and the body is very marked.

Apaiang, Gilbert Islands; Andrew Garrett.

Typhlops Wiedii Pet.

The colors of *T. Wiedii* are described as "buff above, yellowish inferiorly." The form represented in this collection is brown on the back, with ten longitudinal streaks of light color on the edges of the scales, and is whitish on the lower surface, except under the tail, where the color is like that of the back. A few spots of brown appear on the chin. From mouth to end of snout, whitish. A streak of light color, parallel with the margin but at a distance from the suture, forms a horse-shoe-shaped mark on the rostral; behind this, at each side, there is a streak on the nasal near the hinder edge, from the labials upward. Tail dark brown above and beneath.

Cooktown; Mr. Olive.

Enygrus Bibronii H. J.

Rows of scales around the body, 31; scutes, 213 + 55; labials, 12 above, 14 below.

Levuka, Ovalau Island, Fiji; Mr. Alexander Agassiz.

'Dendrophis calligaster Günt.

Length, 332 + 153 millim. Rows, 13; scutes, 180, anal divided, plus 134 pairs of subcaudals. Back nearly uniform light brown; edges of scales narrowly bordered with darker; ventral keels in a whitish line; abdomen sprinkled with small spots of black.

Cooktown; Mr. Olive.

Platurus colubrinus Gir.

Hydrus colubrinus Schn.

The expedition brought back a number of specimens from the Fijis. On three of those counted the rows of scales are 23, 24, 23, and the scutes are 233, anals two pairs, plus 40 subcaudals, 234, anals two pairs, plus 36 subcaudals, and 208, anals two pairs, plus 40 subcaudals. The bands of black on four specimens are 31 + 5, 31 + 3, 29 + 5, and 27 + 4.

Pseudelaps diadema Jan.

Calamaria diadema Schl.

Length 163 + 33 millim. Rows, 15; scutes, 175, anal divided, plus 53 pairs of subcaudals. Brownish red; darker on head and nape, with a transverse yellowish occipital band. Belly yellowish to the upper edge of the second dorsal row. Upper edge of next to outer row and both edges of other dorsal rows, except outer, longitudinally marked with brown, forming zigzag vittæ, of which the median two on the dorsum are confluent.

Cooktown; Mr. Olive.

Denisonia vagrans, var. nov.

Body cylindrical; belly rounded ; tail nearly one-fifth of the total, slender, tapering. Head scarcely distinct from the neck, angular, flattened on the crown. Scales smooth, dorsals in 17 rows; 161 ventrals; a divided anal ; 49 subcaudals, entire. Eye longer than its distance from the end of the snout. Rostral broader than deep, visible from above, in contact with six scales. Internasals broadly in contact with the rostral, little shorter than the prefrontals. Frontal twice as long as broad, one and one-half times as wide as the supraocular, one and one-third times as long as its distance from the end of the snout, shorter than the parietals. Nasal entire, elongate, in contact with the single preocular. Prefrontals bent downward on the side of the face. Preocular in contact with the second and the third labials, the nasal, the prefrontal, and the supraocular. Third and fourth labials below the orbit; fifth labial largest, longer than the sixth. Lower of the two postoculars resting in a notch between the fourth and the fifth labials. Temporals, two plus two, upper anterior largest, lower wedged between the fifth and the sixth labials. Lower labials seven, second smallest, fourth largest, anterior three in contact with the first chin shields, first separating the anterior submental from the mental. Posterior submentals longest, separated from the anterior ventral plates by three longitudinal series of three small scales each.

Uniform brownish olive on the back; belly olivaceous, slightly darkened under chin and throat, whiter under the tail. A narrow band of white behind the eye, shorter than the head. A narrow obsolescent streak below the nostril to the angle of the mouth.

Total length, 0.389 m.; tail, 0.071 m.

Dunk Island, off N. E. coast of Queensland; Dr. W. McM. Woodworth.

The Dunk Island snake is so closely allied to *D. signata* Jan. that it may be placed as a variety. The most prominent differences appear in the frontal shields, the sixth labial, and the coloration. *D. signata* has a darker color in the middle of the ventral surface which is not seen in the present type. The absence of this dark color beneath is what might be expected in a locality with more of vegetation as compared with an arid or desert region.

Crocodilus Johnsoni Krefft.

Cooktown ; Mr. Olive.

Rana Dæmeli Garm.

Hylorana Dæmeli Steind.

There is no doubt whatever of identity of the present form with that figured and described by Steindachner, but it differs so widely from Lesson's figure and description of *Rana papua* as to afford no warrant for union with that species.

Cooktown; Mr. Olive.

Limnodynastes dorsalis Günt.

Cystignathus dorsalis Gray.

Cooktown; Mr. Olive.

Hyla gracilenta Pet.

As represented here the tympanum is distinct, the pollex rather distinct and prominent, and there are no light lines on the sides of the head.

Cooktown; Mr. Olive.

Hyla cærulea Boul.

Rana cærulea White.

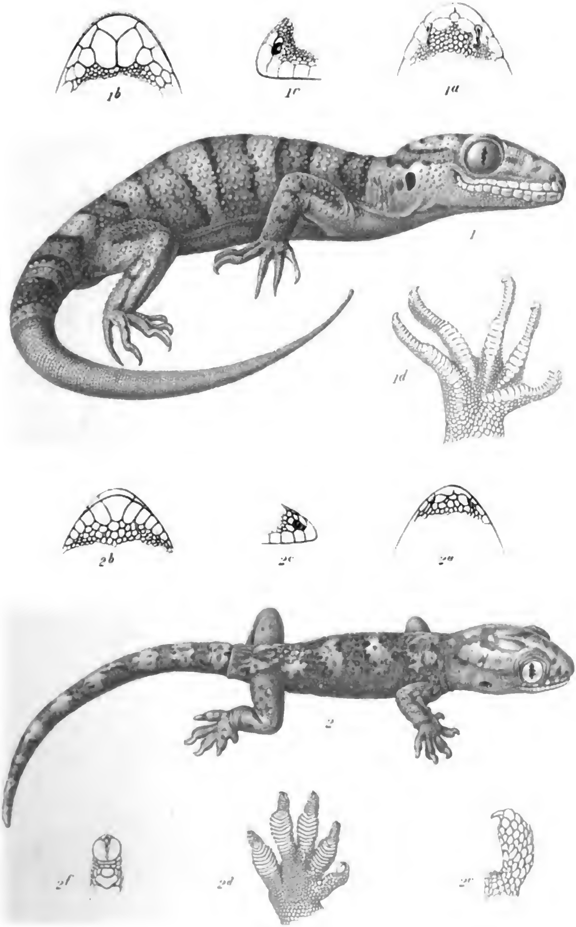
Color uniform blue-green above, unspotted; a line of light color along the tarsus and along the forearm and the hand. Chin white, with a blue-green band extending forward near the lip from the shoulder, not quite reaching the symphysis of the lower jaws. Lower surfaces light, the color separated from the white tarsal and carpal lines by darker.

Port Bowen and Townsville; Dr. Woodworth.

PLATE 1.

Fig. 1. *Gymnodactylus Olivii.*
Fig. 1ᵃ. Upper view of snout.
Fig. 1ᵇ. Lower view of snout.
Fig. 1ᶜ. Side view of snout.
Fig. 1ᵈ. Lower view of foot.

Fig. 2. *Woodworthia digitata.*
Fig. 2ᵃ. Upper view of snout.
Fig. 2ᵇ. Lower view of snout.
Fig. 2ᶜ. Side view of snout.
Fig. 2ᵈ. Lower view of foot.
Fig. 2ᵉ. Side view of toe.
Fig. 2ᶠ. Lower view of inner digit.

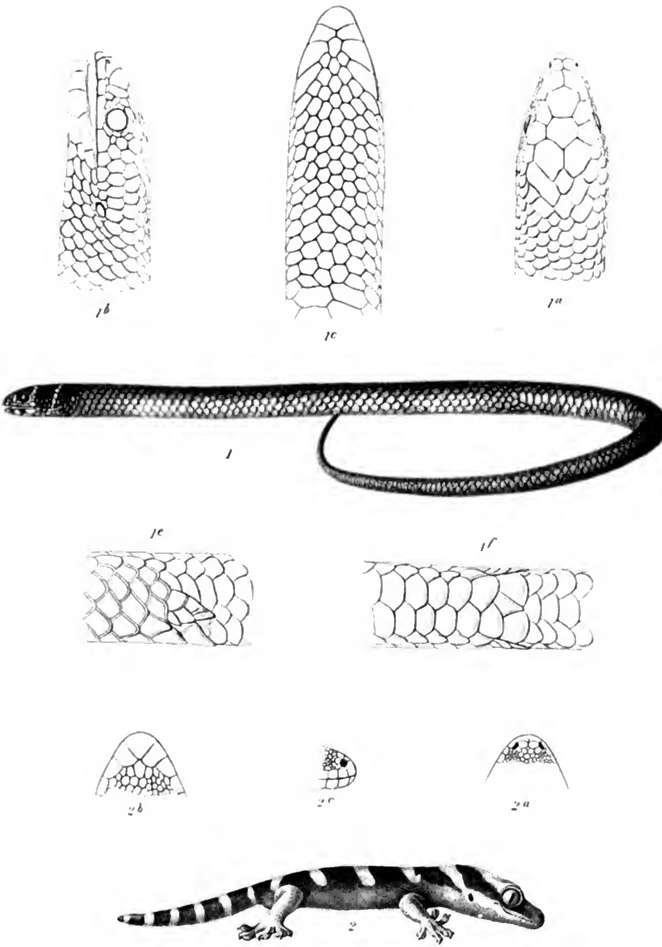


J. Henry Blake del. B. Meisel lith. Boston.

PLATE 2.

Fig. 1. *Delma reticulata.*
Fig. 1a. Upper view of head.
Fig. 1b. Side view of head.
Fig. 1c. Lower view of head.
Fig. 1e. Side view of ventral region.
Fig. 1f. Lower view of ventral region.

Fig. 2. *Œdura Mayeri.*
Fig. 2a. Upper view of snout.
Fig. 2b. Lower view of snout.
Fig. 2c. Side view of snout.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2a
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Bulletin of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

Vol. XXXIX. No. 2.

CHIRIQUI MAMMALIA.

By Outram Bangs.

CAMBRIDGE, MASS., U. S. A.:
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April, 1902.

No. 2. — *Chiriqui Mammalia.* By Outram Bangs.

For nearly a year Mr. W. W. Brown, Jr., collected in Chiriqui for my brother, Edward A. Bangs, and myself. During this time he obtained, in addition to an extensive series of birds, an account of which I have already published,[1] upwards of 500 mammals. These have been presented to the Museum of Comparative Zoölogy, and form the subject of the present paper.

Chiriqui is a region of considerable interest, both from its position between Costa Rica and Panama, and from the lofty Volcan de Chiriqui, which rises to a height of 11,500 feet, and with its slopes and foot-hills forms the principal part of the small province of Chiriqui. Our present knowledge of the mammals is confined wholly to those of the foot-hills with an altitude of from 600 to 800 feet. Mr. H. J. Watson, the owner of extensive plantations at Bogaba, has sent many mammals to the British Museum. From this source Dr. Oldfield Thomas has described a number of new species, and Mr. G. S. Miller, Jr., one species. Unfortunately Dr. Thomas has not published a list of the species sent him; he has described such as were new, and his descriptions are not only scattered, but extend over a period of several years.

The stations at which Mr. Brown collected are as follows: Divala, situated in the lowland forested country, practically sea level; Pedregal on the Pacific coast; Bogaba, in the foot-hills of the Volcan de Chiriqui, 600 feet altitude, aneroid (800 feet according to Dr. Oldfield Thomas); Boquete, on the southern slope of the Volcan de Chiriqui, 3,000 to 5,000 feet altitude (some specimens even up to 7,000 feet, labelled "Boquete," were taken directly above that little village); and the summit of the Volcan de Chiriqui at and near timber line, 10,000 feet and upwards. Thus Mr. Brown covered the various life zones of the Volcan de Chiriqui and the results are of the greatest interest.

[1] Auk, Vol. XVIII. pp. 355–370, Oct. 1901, and Proc. New Eng. Zoöl. Club, Vol. III. pp. 15–70, Jan. 30, 1902.

The forms from the top of the Volcano are very different from those of the lowlands and foot-hills. In my paper in the Proceedings of the New England Zoölogical Club I give extracts from Mr. Brown's itinerary, which, though of interest to mammalogists as well as ornithologists, need not be repeated here.

Mr. Brown took the altitudes with an aneroid.

The mammals that have been described from Chiriqui are as follows: *Caluromys laniger pallidus* Thomas, *Tylomys watsoni* Thomas, *Oryzomys tectus* Thomas, *Proechimys centralis chiriquinus* Thomas, *Dasypterus ega panamensis* Thomas, *Artibeus watsoni* Thomas and *Promops nanus* Miller, all from Bogaba, while *Sciurus melania* (Gray) was named from Point Burica, Costa Rica, just north of Chiriqui, and *Galera barbara biologiæ* (Thomas) was founded on a specimen from Calovevora, Veragua, Panama, just south of Chiriqui. Mr. Brown secured specimens of all of these except *Oryzomys tectus*, *Dasypterus ega panamensis*, *Artibeus watsoni*, and *Promops nanus*.

In the present paper I describe as new one genus, *Syntheosciurus*, and fourteen species and four subspecies: — *Tayassu crusnigrum*, *Sciurus æstuans chiriquensis*, *Sciurus browni*, *Syntheosciurus brochus*, *Megadontomys flavidus*, *Peromyscus cacabatus*, *Nyctomys nitellinus*, *Sigmodon austerulus*, *Oryzomys devius*, *Oryzomys vegetus*, *Reithrodontomys australis vulcanius*, *Reithrodontomys creper*, *Akodon teguina apricus*, *Akodon xerampelinus*, *Macrogeomys cavator*, *Macrogeomys pansa*, *Heteromys repens*, *Agouti paca virgatus*.

The systematic sequence is that of Miller and Rehn in their recent list. All the measurements are in millimeters, and except the skull measurements, which are mine, are those of the collector. Color names are according to Ridgway's nomenclature. As descriptions of skulls are frequently inadequate, I give figures, from the drawings of Dr. J. C. McConnell, in all cases of importance.

In the identification of the species I have been assisted by Mr. Gerrit S. Miller, Jr., Mr. E. W. Nelson, and Mr. W. H. Osgood, to all of whom I express my sincerest thanks. Dr. J. A. Allen, of the American Museum of Natural History, and Dr. C. Hart Merriam, of the United States Biological Survey, have most kindly loaned specimens that were of the utmost importance.

Marmosa mexicana (Merriam).

Four specimens, an old adult ♂ from Boquete, 4,000 feet, and three young from Bogaba, 600 feet, February and July.

These appear to be identical with specimens from Southern Mexico, States of Chiapas and Vera Cruz. The old ♂ is much larger than any Mexican example I have seen, but is much older also, and the difference in size seems to be wholly due to age. *M. mexicana* is a very distinct species, differing from the South American forms of the *M. murina* series in its reddish chestnut coloring, without olive shades, and certain cranial characters; the nasals are short and truncate posteriorly, the interorbital region wide, the supraorbital beading slight; a still more marked character is the two parallel temporal ridges, extending the length of the brain case and ending one on each side of supraoccipital.

M. mexicana is wholly different from *M. fulviventer*, lately described by me from San Miguel Island, Bay of Panama.

The old adult ♂ No. 10,154, measures, total length, 370; tail vertebræ, 195; hind foot, 25; ear, 25. Skull, basal length, 38.4; occipitonasal length, 41; zygomatic width, 22.2; length of nasals, 17.8.

Caluromys laniger pallidus (Thomas).

Type Locality. — Bogaba, Chiriqui.

Six adults, both sexes. Bogaba and Divala, November, December, and July.

Metachirus fuscogriseus Allen.

Four adults, both sexes, Boquete, 4,500 feet, and Bogaba, March and July. These specimens are referable in every way to Dr. Allen's species, the type locality of which was not known. Dr. Allen, however, later refers Nicaraguan examples to it; thus the range of *M. fuscogriseus* extends certainly from Nicaragua to Chiriqui. The largest individual, No. 10,146, ♂ old adult, measures, total length, 620; tail vert., 315; hind foot, 47; ear, 33.

Didelphis richmondi Allen.

Type Locality. — Greytown, Nicaragua.

Six adults, both sexes, Boquete, 4,000 to 5,800 feet, March.

Dr. Allen now refers Costa Rican specimens, that he formerly called *D. aurita*, here. Mr. Brown's record carries the range of the species a little farther south. All the examples agree in every way — size, color, color pattern, skull characters — with Dr. Allen's description.

Choloepus hoffmanni Peters.

Five specimens, both sexes, young and adult, Boquete, 4,000 to 4,800 feet, and Bogaba, March, April, and July.

Cyclopes dorsalis (Gray).

Nine specimens, both sexes, young and adult. Divala and Bogaba, December and July.

Although in September, 1900, Dr. Oldfield Thomas pointed out anew the differences between the Central American *C. dorsalis* and the typical *C. didactylus* of Guiana, and though it had stood in Trouessart's Catalogue as a subspecies, it is omitted by Miller and Rehn in their recent list.

Uroleptes sellata (Cope).

Two specimens; adult ♀, Divala, December; adult ♂, Volcan de Chiriqui, 5,000 feet, May.

Myrmecophaga tridactyla Linn.

One adult, Divala, December.

Tayassu crusnigrum, sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,163. Young ad. ♂, Boquete, April 13, 1901, 4,000 feet.

Three specimens, both sexes, one young, one young adult, one old adult, Boquete, 4,000 to 5,800 feet, March and April.

Characters. — Probably nearest to *T. angulatus humeralis* Merriam (Mexico, Colima to Tehuantepec), but much darker throughout; legs and arms almost wholly black; dorsal black band wide; shoulder stripes wide and conspicuous, tawny in color; pelage rough and coarse; skull wider above and narrower below; rostral portion wider; palate much narrower, tooth rows nearer together.

Color. — Legs, arms, central dorsal, and central ventral stripes, black; rump mostly black, a few of the hairs (bristles) annulated with tawny; conspicuous shoulder stripes, tawny; sides of head and of body, mixed tawny and black; all the hairs annulated with these colors; hairs on outer surface of ears mostly black, those on inner surface mostly tawny, the general effect being that of a very dark, richly colored peccary.

Measurements —

No.	Sex.	Total length.	Hind foot (with hoof).	Ear.
10,162	old ad. ♀	1030	170	80
10,163	type ; young ad. ♂	860	145	76
10,164	young ♀	775	135	72

Skull, No. 10162, old adult ♀, from Boquete 5,800 feet, basal length, 197; occipitonasal length, 222; zygomatic width, 103; greatest width across squamosals posteriorly, 98 ; palatal length to palatal notch, 140 ; breadth of basioccipital between bullæ posteriorly, 19 ; length of upper molariform series, 64.

Remarks. — I do not give this fine new peccary as a subspecies of ***Tayassu angulatus*** (Cope) because the relationships of the North American forms and the South American *T. tajacu* are not as yet clearly understood. It is very different from any of the forms lately described by Doctor Merriam, and is even more widely separated from my *T. torvus* of the Santa Marta region of Colombia. The two younger specimens agree in coloration, but the old ♀, No. 10,162, is slightly different; the bristles of the rump are rather more annulated, and the color of the lighter rings on the bristles here and on the sides is paler — yellowish white instead of tawny. The color of the shoulder stripes and the head and neck is as in the other species. It is in rather worn pelage, and as these differences may be due to actual fading, I select a younger individual, in fine pelage for the type.

A white-lipped peccary also occurs in Chiriqui. Mr. Brown saw them several times, but those wounded escaped in the dense jungle.

Odocoileus[1] sp. ?

One young ♂, Boquete, 4,000 feet, April 10. This specimen is in the spotted pelage, and is too young to identify. The species was rare, but was well known to the native hunters.

Mazama sartorii (Saussure).

Three adults, two males and a ♀, Boquete, 4,000 to 4,800 feet, March and April.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,158	old ♂	1330	. .	260	84
10,159	old ♂	1340	100	255	76
10,160	old ♀	1360	105	240	78

[1] For use of Dama instead of Odocoileus, see Allen, Bull. Am. Mus. N. H., Vol. XVI. pp. 18–20, Feb. 1, 1902. I am as yet not satisfied as to the correctness of Dr. Allen's contention.

Elasmognathus bairdii Gill.

One fine old adult ♂, Boquete, 5,000 feet, March.

Sciurus (Echinosciurus) melania (Gray).

Twenty-one specimens, adults of both sexes, and young, Divala, Bogaba, and Boquete, 2,000 feet, November, December, January, and July.

This fine, large black squirrel, described by Gray in 1867 from Point Burica, Costa Rica, was unknown to Nelson when he wrote his Revision of the Squirrels of Mexico and Central America. In a foot-note on page 74 he says: "This may be a valid species or subspecies, but the type was evidently a melanistic specimen, and in the absence of material I refer it here" (to *Sciurus adolphei dorsalis* (Gray)). The large series collected by Brown shows that Gray's type was not melanistic, and that the animal is a fine distinct species. It probably has a very restricted range; so far as I know, it has not been taken in Costa Rica, north of the very southern part, bordering Chiriqui, the locality of Gray's type. It is a low land species, and not found high up the Volcan de Chiriqui, 2,000 feet being the extreme altitude at which Mr. Brown saw it, and but once so high as that. About Bogaba (600 feet) and Divala, it is common and generally distributed in suitable places.

In normal, fresh pelage it is nearly black all over, the back only being a dark chocolate. As the pelage becomes shabby from wear, the back and tail fade to a dull yellowish brown color, the rest of the animal remaining dull black. In many of these faded specimens, fresh hairs appear in patches, and these are of the normal, beautiful dark chocolate color. *Sciurus melania* is a beautiful squirrel, the pelage has a sheen quite peculiar, and the chocolate of the back is very rich, an unusual color in mammals. The young are like the adults. Fully adult specimens usually measure, total length, 500 ; tail vertebræ, 260 ; hind foot, 63 ; ear, 30. The very largest have a total length of 560.

Sciurus (Guerlinguetus) æstuans chiriquensis, subsp. nov.

Type. — Mus. Comp. Zoöl. No. 10,044, ad. ♂, Divala, Nov. 18, 1900.

Forty-one specimens, both sexes, young and adult, Divala, Boquete, and Volcan de Chiriqui, 4,000 to 7,500 feet, and Bogaba, November, December, February, March, April, and July.

Characters. — Very similar to *S. æstuans hoffmanni* Peters from Costa Rica in all respects, except a constant, well-marked difference in general coloration. The under parts, paler, yellower, less brick-red ; the upper parts more olivaceous, less bricky-red. A large series of the two forms shows this difference in color to be well marked at all seasons.

Color and *Pelage.* — Pelage, short and rather hispid, with scarcely any underfur. Upper parts, finely mixed (owing to the annulations of the hairs) blackish brown (perhaps nearest mummy brown) and tawny, the tawny color predominating on sides, the dark brown color along middle of back; orbital ring, back of ear and a small spot just behind ear clear tawny; under parts tawny, becoming yellower, about raw sienna on under side of neck and head, and often the breast similarly colored; tail much the same as back, but with the tawny annulations wider; deeply fringed along sides with clear tawny, under side darker than upper.

Variations in Color. — The large series before me presents very little color variation, and apparently no seasonal variation in color; a few specimens only in very worn pelage are duller, more rusty brown above, due to actual fading; the amount of the yellowish color (raw sienna to ochraceous) that always occupies the under side of head and neck varies in different individuals — in two extreme specimens, Nos. 10,416, and 10,038, ♀ and ♂ adults, it covers the whole under parts, there being no tawny. There are also three albinistic specimens, irregularly marked with white on under parts and feet.

Skins from the Volcan de Chiriqui from upwards of 4,000 feet altitude are more woolly with decidedly more under fur than lowland examples, but otherwise they do not differ.

Measurements (ten adults type and topotypes)—

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,044 type	♂	400	190	52	20
10,038 topotype	♂	460	190	55	18
10,042 do.	♂	460	220	55	24
10,040 do.	♂	440	185	53	20
10,047 do.	♂	440	185	54	22
10,041 do.	♂	425	190	57	23
10,036 do.	♀	410	180	55	23
10,045 do.	♀	410	180	54	23
10,043 do.	♂	410	180	56	24
10,039 do.	♂	395	185	54	24

Skull, type, adult ♂, basal length, 46.2; occipitonasal length, 54; zygomatic width, 31.4; length of nasals, 16.4; length of palate, to palatal notch, 23.2; to end of pterygoid, 30.

Remarks. — This new form which is found apparently throughout Chiriqui, in suitable places, is a slightly differentiated southern race of *S. hoffmanni* of Costa Rica. It is distinguished by paler under parts, which are much yellower, less brick-red, and by the different shade of the upper parts. I do not believe that *S. hoffmanni* is a subspecies of *S. æstuans* of South America, but as this has been the view taken by recent reviewers of the group, for the sake of uniformity I so treat it here.

Sciurus (Microsciurus) browni,[1] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,404, old ad. ♂ Bogaba, July 15, 1901.

Five specimens, both sexes, Bogaba, July.

Characters. — Probably nearest to *S. alfari* Allen, from Costa Rica, but differing in many respects from that species. Pelage *much* thinner, less woolly; upper parts decidedly more olivaceous — lacking the reddish brown of *S. alfari*; tail thinly washed with grayish white instead of dull rusty; nose, forehead, and orbital ring more tawny; under parts *much* paler; in the new species dull gray slightly washed with buffy in some specimens, yellowish white in others, on under side of neck and middle of belly, in *S. alfari* the under parts are dull rusty on under side of neck and breast with a thin wash of this color extending back over belly, which has a dull brown shade.

The skull is similar to that of *S. alfari*, but the brain case is narrower, more rounded and without so marked a constriction in front of the occiput, and with the mastoid region less prominent.

Color and *Pelage.* — Pelage short and thin, rather harsh and with but little under fur.

Upper parts, a fine mixture of tawny olive and bistre, produced by the dark brown bases and tawny olive tips of the hairs; nose, forehead, and orbital ring tawny; tail with the hairs dark reddish brown basally then black and tipped with grayish white, a small black pencil; under parts dull gray to grayish white, slightly washed with buffy or yellowish (in some specimens, very slightly in the type) on under side of neck and middle of belly; under sides of legs darker — more nearly like upper parts.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,404 type	♂ ad.	260	120	38	14
10,405	♀ ad.	255	100	38	14
10,407	♀ ad.	232	110	38	13
10,406	♀ ad.	250	110	36	14
10,408	♂ youngish	245	110	37	13

Skull, type, adult ♀, basal length, 29; occipitonasal length, 36; zygomatic width, 21.2; interorbital width, 12.4; palatal length, to palatal notch, 13.4; to end of pterygoid, 20.2; length of nasals, 11; length of upper molar series, 5.8.

Remarks. — Mr. Brown found this little squirrel in the forest about Bogaba, at 600 feet altitude. It was rare and exceedingly hard to get, on account of its small size and dull coloring, and only by devoting much time and energy to the chase did he succeed in taking five specimens.

Mr. E. W. Nelson has compared very carefully these five specimens with the type of *Microsciurus alfari* Allen, and agrees with me as to the specific differences between these two tiny tree squirrels.

[1] Named for Mr. W. W. Brown, Jr.

Syntheosciurus,[1] gen. nov.

Type: *Syntheosciurus brochus*, sp. nov.

Characters. General external appearance much as in *Microsciurus*, but ear still smaller, hardly standing up above the fur, and very woolly; pelage very long, dense, and woolly; size larger than usual in *Microsciurus;* skull and teeth peculiar; skull very thin and papery, with very small, feeble, constricted rostrum, with the upper outline (of rostrum) straight; audital bullæ small; molar teeth as in *Microsciurus* and peg-like premolar *present;* incisors very slender and projecting outward (not curved under as usual in tree squirrels); upper incisors with a *well-marked central groove* down each.

Syntheosciurus brochus,[2] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,402, ad. ♂, Boquete, April 30, 1901. 7,000 ft.

Two adults, ♂ and ♀, Boquete, 7,000 ft. altitude, taken together on April 30.

Characters. — Size intermediate between *Microsciurus* and *Guerlinguetus;* tail a little less than length of head and body, full and bushy; ear very low, round, and woolly; pelage very long, soft, and woolly, with very thick under fur; general coloration dark reddish olive, with under parts varying from orange rufous to ferruginous; no distinct line of demarcation between colors of upper and under parts; skull and incisor teeth peculiar (as pointed out in the description of genus).

Color. — Upper parts finely mixed olivaceous bistre and dull tawny olive — the hairs olivaceous bistre, tipped with dull tawny olive; under fur dark mouse-gray; orbital ring, sides of nose and chin tawny olive; tail similar to back, fringed along sides with pale rusty and slightly more reddish, less olivaceous below; under parts, especially along middle line, strongly suffused with orange rufous in the type (ferruginous in No. 10,403, nursing female).

Measurements —

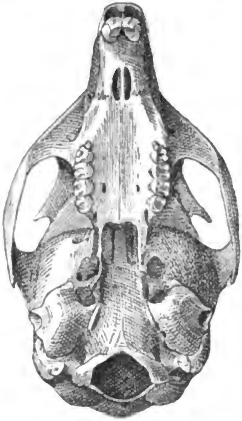
No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,402 type	♂ ad.	320	150	46	17
10,403	♀ ad.	315	145	46	16

Skull type, adult ♂, basal length, 35.6; occipitonasal length, 44; zygomatic width, 25.2; interorbital width, 12.6; palatal length, to palatal notch, 20; to end of pterygoid, 27.4; length of nasals, 13; width of nasals, 5.8; length of upper molar series, 7.6; length of single half of mandible, 27.

Remarks. — Mr. Brown met with this remarkable squirrel but once, when he took the pair described. It was unknown to the native hunters who ac-

[1] Σκίουρος = squirrel, and Σύνθετος = combined.
[2] *Brochus*, with projecting teeth.

companied him, and who expressed much astonishment on being shown the two examples. Judging by the long, dense fur, even at this time of year —



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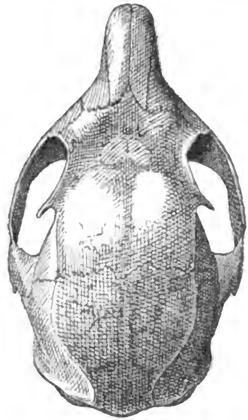

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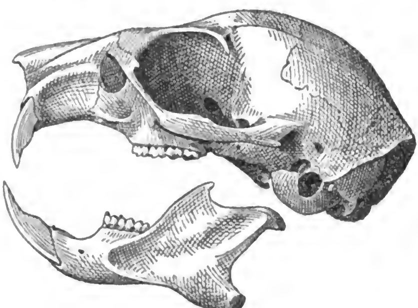

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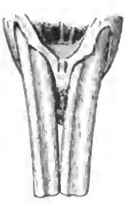


4. × 4

FIGS. 1, 2, 3, AND 4. *Syntheosciurus brochus.* Type.

April 30 — when the female was nursing young, it is evidently an animal of high elevations only.

Among tree squirrels, *Syntheosciurus brochus* has no very near ally; its light, papery skull recalls that of *Sciuropterus*, but the audital bullæ are much smaller. Its peculiarly straight, slender rostrum, weak, projecting, and *grooved* incisors at once distinguish the genus from any other.

Mus rattus Linn.

One youngish ♀, Boquete, 4,800 ft. Mar.

Megadontomys[1] flavidus,[2] sp. nov.

Type. — Mus. Comp. Zoöl. No. 10,331, ad. ♂, Boquete, April 12, 1901. 4,000 ft.

Twenty-seven specimens, Boquete, 3,000 to 5,000 ft., February and April.

Characters. — A large species, much paler and yellower than *M. thomasi* Merriam, Mountains near Chilpancingo, Mexico, 9,700 ft., and *M. nelsoni* Merriam, Jico, Mexico, altitude 6,000 ft.; skull with much more rounded and elevated and less flattened brain case; palatal slits very wide; audital bullæ decidedly small; ears small.

Color. — Upper parts brownish cinnamon, usually rather more rusty toward rump, brighter, inclining toward orange-buff along lower sides; a large, conspicuous blackish patch on each side of head at base of whiskers; whiskers mixed black and colorless; underparts white, the gray basal portion of the hairs showing through; a slight collar yellowish or buffy; feet and hands whitish, marked with brown about ankles and wrists; tail sparsely clothed with short stiff hairs, dusky above, grayish below; ears nearly naked, dusky outside, slightly silvery inside. Young examples differ from the adults in being darker and duller brown above; the under parts more grayish, less purely white.

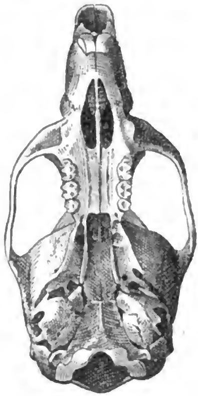
Measurements (of ten adults, type and topotypes) —

No.	Sex.	Total length.	Tail vert.	Hind Foot.	Ear.
10,327	♂ old ad.	375	205	31	23
10,329	♂ old ad.	355	195	32	23
10,333	♂ old ad.	350	185	32	24
10,339	♂ ad.	345	185	32	22
10,336	♂ ad.	345	187	32	23
10,331 type	♂ ad.	336	180	31	23
10,328	♂ ad.	335	155	32	20
10,338	♂ ad.	330	185	32	22
10,342	♂ ad.	325	170	31	23
10,330	♀ ad.	320	165	33	22

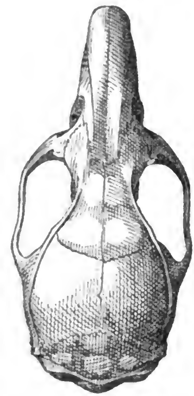
[1] Though described by Dr. Merriam as a subgenus of *Peromyscus*, *Megadontomys* is entitled to generic rank, on account of the unwieldy proportions of Peromyscus.

[2] *Flavidus*, yellowish.

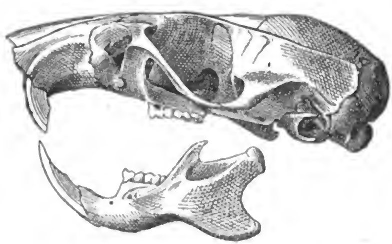
Skull type, ♂ adult, basal length, 35.4; occipitonasal length, 40.2; zygomatic width, 19.6; mastoid width, 15; length of nasals, 17.8; width of nasals, 4.8; length of palatal slits, 7.4; width of palatal slits, 3.4; length of palate, to palatal notch, 17; to end of pterygoid, 24.4; length of upper molar series 5.6; length of single half of mandible, 21.8.



5. × 1¾



6. × 1¾



7. × 1¾

FIGS. 5, 6, AND 7. *Megadontomys flavidus.* Type.

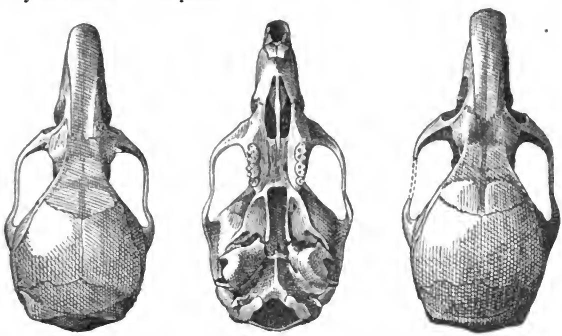
Remarks. — The Volcan de Chiriqui is thus far the southernmost point from which a species of this well-marked group of Vesper Rats has been recorded. *Megadontomys flavidus* was common in the upland forest from 3,000 to 5,000 feet, but was not taken above or below these heights. While showing the group characters quite as strongly as either of its Mexican congeners, *M. flavidus* is very different specifically; its yellowish coloration and rounded elevated brain case at once distinguishing it.

Peromyscus cacabatus,[1] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,225, ad., ♀ Boquete, April 22, 1901. 5,000 feet.

One hundred and thirty-one specimens, Boquete, 4,000 to 7,500 feet, January to April.

Characters. — Probably nearest to *P. guatemalensis* Merriam (Todos Santos, Guatemala, 10,000 feet), tail shorter and colors not so dark; palatal slits shorter and wider; nasals in old age, more expanded at tips, like those of *P. furvus* Allen and Chapman.



8. × 1¾ 9. × 1¾ 10. × 1¾

FIGS. 8 AND 9. *Peromyscus cacabatus.* Type.
FIG. 10. *P. cacabatus*, very old ♂. No. 10,202, to show expansion of nasals in old age.

Color. — A broad dorsal band sooty, becoming less intense and browner on sides of back and gradually passing into dull orange-buff on lower sides; sides of nose, at base of whiskers, dull grayish or buffy white; top of nose, space between base of whiskers and eye, and orbital ring black; under parts — a broad pectoral collar, dull orange-buff, rest of under parts varying from dull grayish white to strong pinkish buff, — usually with chin and throat grayish white, and belly grayish white, washed with pinkish buff —; feet and hands, whitish; ears, nearly naked, dusky; tail nearly naked, dusky above, usually pale, yellowish gray below (the tail is very variable, the paler color below is

[1] *Cacabatus*, sooty (color).

often in patches, or spots, sometimes occupying nearly the whole of the under surface, sometimes wholly wanting; and in some specimens the upper surface also is patched with whitish). Very old examples are paler above with the sooty dorsal stripe, less well marked; younger specimens are darker, often with most of the back sooty.

Measurements (of ten adults, type and topotypes). —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,204	♂ old adult	270	135	26	21
10,202	♂ old ad.	265	128	26	21
10,218	♀ old ad.	265	130	25	21
10,211	♂ old ad.	265	125	25	20
10,199	♂ ad.	260	126	26	20
10,225	♀ ad. (type)	260	128	26	20
10,205	♂ ad.	257	125	26	20
10,212	♂ ad.	255	120	26	20
10,244	♀ ad.	255	120	27	21
10,198	♂ ad.	252	120	26	21

Skull, type, adult ♀, basal length, 28.8; occipitonasal length, 32.4; zygomatic width, 15.6; mastoid width, 13.6; length of nasals, 13; width of nasals, 3.4; length of palatal slits, 6.2; width of palatal slits, 3.2; length of palate, to palatal notch, 12.8; to end of pterygoid, 19; length of upper molar series, 5; length of single half of mandible, 17.4.

Remarks. — *Peromyscus cacabatus* was by far the commonest small mammal of the mountain forest belt of the Volcan de Chiriqui. It does not appear to occur below 4,000 feet, and extends from thence upward to the limit of the life zone it occupies, roughly speaking, about 8,000 feet, 7,500 feet is the highest altitude marked on any of the labels. The Mount Chiriqui Peromyscus, is most nearly allied to *P. guatemalensis* and *P. furvus*, but is quite distinct. It is the most southern member of the genus thus far recorded.

Nyctomys[1] nitellinus,[2] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,249, old ad. ♀, Boquete, Feb. 8, 1901. 4,000 feet.

Six specimens, Boquete, 4,000 to 6,000 feet, January, February, and March.

Characters. — Apparently a very distinct species, though nearest to *N. decolorus* (True) from Rio de las Piedras, Honduras. Color of back, pale and yellowish, but decidedly darker than in *N. decolorus*. Also larger than *N. decolorus;* tail more hairy; skull much larger, with narrower posterior part;

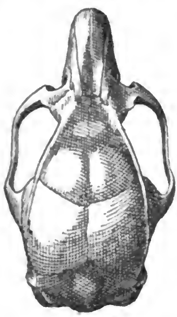
[1] I think all mammalogists must now regard the very well marked Central American hairy-tailed Vesper rats, as generically distinct from *Rhipidomys*. The important characters are four instead of six mammæ, very slender, short rostrum, exceedingly short palatal slits and peculiarly expanded brain case. The synonymy is: *Nyctomys* Sauss. 1860; type, *N. sumichrasti; Myoxomys* Tomes, 1861; type, *M. salvini*.

[2] *Nitellinus*, like a dormouse.

interparietal narrower; palatal slits much narrower and longer — less rounded in shape.

From *N. sumichrasti* or *N. salvini* (probably distinct species, as suggested by True, Proc. U. S. Nat. Mus., Vol. XVI. p. 690), the new species differs in its much yellower less ferruginous color above, in its blackish ears and tail, and in its larger size.

Color. — Upper parts, yellowish cinnamon, duller, more isabella color on top of head, darkened along middle of back, head, and rump by a slight admixture of brown tipped hairs; lower sides brighter, decidedly shaded with orange-buff; orbital ring and space between base of whiskers and eye black; top of nose pale isabella color; whiskers, very long, mixed black and colorless; under parts, pure, snowy white to base of hairs; ears, sparsely haired dusky; tail



11. × 1¾

12. × 1¾

FIGS. 11 AND 12. *Nyctomys nitellinus.* Type.

well haired, the hairs gradually becoming longer toward tip, and ending in a pencil, unicolor, blackish; hands white; feet — toes and sides of tarsus white, central portion of tarsus, dark brown.

The type and Nos. 10,245 and 10,246 are practically alike in color, the other three, all younger, are paler, grayer, more isabella color above; the lower sides are cinnamon without the bright orange-buff shade of the older specimens.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,247	♀ ad.	250	120	25	17
10,248	♀ ad.	250	125	25	17
10,249 type	♀ old ad.	260	125	24	17
10,250	♂ young	215	90[1]	23	16
10,246	♂ old ad.	240	107[1]	22	17
10,245	♂ ad.	185	55[1]	25	17

[1] End of tail gone.

Skull, type, ♀ old adult, basal length, 28; occipitonasal length, 32.4: zygomatic width, 18; mastoid width, 13; interorbital width, 11; length of nasals, 10.6; width of nasals, 3.2; length of palatal slits, 4.6; width of palatal slits, 2.2; length of palate, to palatal notch, 12.4; length of upper molar series, 4.8; length of single half of mandible, 18.

Remarks. — I have compared the series of *N. nitellinus* with the type of *N. decolorus* and the other species of this group in the United States National Museum, and while most nearly allied to the species from Honduras, I find excellent specific characters, both external and cranial for the separation of *N. nitellinus*.

Tylomys watsoni Thomas.

O. Thomas, Ann. and Mag. of N. H., 7th Series, IV., p. 278, 1899.

Type locality. — Bogaba, Chiriqui.

Four specimens; adult ♂ and ♀ and a young ♂, Bogaba, July, and a half grown young one from Boquete, 5,600 feet, March.

The specimens from Bogaba are not only topotypes, but were caught on the banks of the same stream as the type.

Measurements of the four specimens —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,254	♀ old ad.	455	235	40	27
10,251	♂ old ad.	440	235	42	25
10,252	♂ yg. Boquete.	380	195	35	22
10,253	♂ very yg.	260	125	32	18

Sigmodon borucæ, Allen.

Three adults, Bogaba, July.

These appear to be identical with Allen's *S. borucæ* of Boruca, Costa Rica. The measurements are —

No.	Sex.	Total length.	Tail vert.	Hind foot	Ear.
10,287	♀ old ad.	280	105	32	19
10,285	♂ ad.	260	110	30	17
10,286	♂ yg. ad.	245	100	30	18

Sigmodon austerulus,[1] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,288, ad. ♂, Volcan de Chiriqui, June 1, 1901. 10,000 feet.

Characters. — About the size of *S. borucæ;* tail longer; pelage much more hispid; colors all much paler; skull similar.

[1] *Austerulus*, somewhat harsh.

Color. — Upper parts cinnamon brown darkened along middle by the admixture of dark brown tipped hairs, somewhat shaded with russet on rump and flanks; under parts white washed with pale buff, sharply contrasted against color of upper parts; ears dusky with some hairs on both surfaces colored like those of the back; feet and hands yellowish gray (much paler than in *S. borucæ*), tail thickly clothed with short, stiff, close hairs, dusky above, gray below.

Measurements. — Type, adult ♂, total length, 260; tail vertebræ, 120; hind foot, 32; ear, 17.

Skull (an adult with somewhat worn teeth; unfortunately it was broken by the trap directly across between the orbits) — mastoid width, 14.8; upper molar series, 6; length of single half of mandible, 19.2.

Remarks. — The Sigmodon of the low lands of Chiriqui is a small dark colored species with very soft pelage, that I cannot distinguish from *S. borucæ* of the low lands of Costa Rica.

When Dr. Allen described that animal he spoke of specimens from San José 5,000 feet altitude, that had hispid pelage, but otherwise did not differ.

The one example from the top of the Volcan de Chiriqui, differs from *S. borucæ* of the adjacent low lands not only in having much more hispid pelage, a much paler coloration throughout, but also a longer tail.

In the forest belt of the Volcan, where Mr. Brown did much trapping, he did not find Sigmodon, and for that reason I give full specific rank to the form of the summit of the Volcan de Chiriqui. It has been my experience that Sigmodons love open fields, savannahs, brushy places, and waste land, and avoid the dense forest.

Oryzomys alfaroi (Allen).

Fourteen specimens, Boquete, 4,000 feet, February and April; Divala, December.

I have compared this series with specimens from Tins, Costa Rica (the type locality of the species is San Carlos, Costa Rica) sent me by Dr. Allen, and can detect no differences.

Measurements (of six adults from Boquete) —

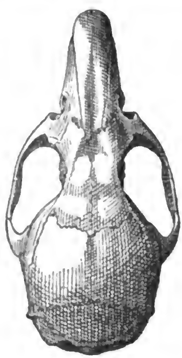
No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,315	♀	235	120	26	16
10,322	♂	225	110	26	16
10,311	♂	225	105	26	15
10,314	♂	215	105	23	15
10,316	♀	215	110	26	15
10,320	♂	210	105	25	15

Oryzomys devius,[1] sp. nov.

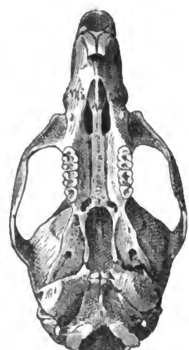
Type. — Mus. Comp. Zoöl., No. 10,324. Young ad. ♀, Boquete, Jan. 29, 1901. 5,000 feet.

Four specimens, Boquete, 4,000–5,000 feet altitude, January and February.

Characters. — A large species belonging to the *Oryzomys meridensis* group. Externally quite like *O. childi* of the Bogota region of Colombia, except in the color of the under parts, which are white and fulvous in patches, instead of being white and gray in patches. The skull shows many good characters distinguishing it from that of *O. meridensis*. It is slightly larger, with longer rostrum, wider between orbits; the palatal slits are about the same length, but much wider; audital bullæ larger.



13. × 1¾.



14. × 1¾.

FIGS. 13 AND 14. *Oryzomys devius.* Type.

Color. — Upper parts, rich, lustrous russet-brown, slightly darkened along middle of back by sprinkling of dark brown tipped hairs, paler, brighter, more rufous on sides; top of nose, base of whiskers and region about eye, blackish; upper surface of legs and arms dusky brown; under parts variable (as in all members of this group), under side of head and neck grayish white, a pectoral and a ventral patch, white; the hairs scarcely gray at base, the region between these patches grayish white in No. 10,340, strong ochraceous buff, the hairs deep gray at base in the other three skins; ears large, nearly naked, black; feet and hands yellowish white; tail nearly naked, dusky above, grayish below.

[1] *Devius*, dwelling in lonely places, etc.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,340	♂ old ad.	360	195	35	22
10,326	♀ ad.	345	185	36	23
10,324 type	♀ yg. ad.	335	180	33	22
10,325	♀ yg. ad.	333	165	33	22

Skull. — Type, ♀, young adult, basal length, 31.6; occipitonasal length, 36; zygomatic width, 18; mastoid width, 13.8; interorbital width, 5.6; length of nasals, 14.2; width of nasals, 3.8; length of palatal slits 5.6; width of palatal slits, 2.6; length of palate, to palatal notch 15.6; upper molar series, 5.4: length of single half of mandible, 20.

Remarks. — *Oryzomys meridensis* Thomas, originally described from Merida, Venezuela, has a very extended distribution in South America, and several names have been bestowed upon it in different parts of its range. Dr. Thomas does not look with much favor upon these supposed races, and is inclined to unite them all. Those that I have seen specimens of are, *O. childi* of the Bogota region of Colombia and *O. maculiventer* Allen, of the Santa Marta district of Colombia. I cannot see that these two differ in any way. The Chiriqui form is also similar to these externally, except for the somewhat differently colored under parts; it has, however, good cranial characters to distinguish it.

Oryzomys (Oligoryzomys) costaricensis Allen.

Five specimens, Boquete, 3,800 to 4,800 feet, April and March, Bogaba, July.

The type locality of this species is El General, Costa Rica, 2,150 feet altitude. To it I refer five out of the eighteen specimens of Pigmy Oryzomys that Mr. Brown took in Chiriqui; the other thirteen represent quite a different form.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,294	♀ old ad.	200	105	21	11
10,293	♂ old ad.	190	106	20	..
10,296	♂ ad.	190	105	22	14
10,307	♀ ad.	190	105	21	12
10,299	♂ yg. ad.	180	100	21	12

Oryzomys (Oligoryzomys) vegetus,[1] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,298, old ad. ♀, Boquete, April 16, 1901. 4,000 feet.

Thirteen specimens, Boquete, 4,000–4,800 feet, February and April.

Characters. — Larger than *O. costaricensis;* hind foot larger; ear larger; color above darker, redder, below buffy instead of white; skull larger and

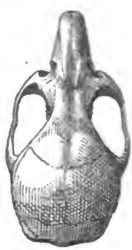
[1] *Vegetus*, active, sprightly.

heavier, wider, especially across forward part of zygoma incisor teeth orange (yellow in *O. costaricensis*).

Color. — Upper parts bright yellowish red brown, darkest along middle of back, and becoming strong orange rufous on rump and sides, sides of head and at base of whiskers; top of nose and head duller and more mixed with dark brown-tipped hairs; chin and under side of neck whitish, rest of under parts ochraceous buff, not sharply contrasted with color of sides; feet and hands yellowish white; ears dark brown outside, inside with hairs — rather sparse — colored like the back; tail dusky above, grayish below. Young examples differ little from the adults, except in being rather duller in color throughout.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,304	♂ old ad.	235	130	24	13
10,306	♀ old ad.	220	130	24	13
10,303	♂ ad.	215	120	25	13
10,298 type	♂ old ad.	210	120	25	14
10,302	♂ ad.	208	115	24	13
10,297	♂ ad.	206	120	24	13
10,295	♂ ad.	205	120	24	13
10,300	♂ yg. ad.	200	118	24	13
10,310	♂ yg. ad.	190	115	24	12
10,305	♂ yg. ad.	190	110	25	12
10,309	♂ yg.	170	98	22	12



× 1¼

FIG. 15. *Oryzomys vegetus.* Type.

Skull. — Type, old ad. ♂, basal length, 20.2; occipitonasal length, 24.4; zygomatic width, 12.6; mastoid width, 11; interorbital width, 3.4; length of nasals, 9; upper molar series, 2.8; length of single half of mandible, 12.4.

Remarks. — *O. vegetus* may prove to be only a northern subspecies of *O. dryas humilior* Thomas of Colombia, Bogota region to Santa Marta region. Though closely allied, the Chiriqui form has a shorter tail, is rather redder above, and slightly paler below, and its skull is decidedly heavier throughout.

On the Volcan de Chiriqui the two species of pigmy Oryzomys occur together. In the Santa Marta Mountains, where two species, *O. dryas humilior* and *O. navus*, also occur, the former was found from 8,000 to 9,000 feet only, and the latter from 3,000 to 8,000, their ranges just overlapping.

Zygodontomys cherriei (Allen).

One youngish ♀, Bogaba, July 3.

I have compared this example with topotypes, kindly loaned by Dr. Allen, and can find no differences. The type locality of the species is Boruca, Costa Rica, in the low lands.

The present specimen, not full grown, measures, total length, 195; tail vertebræ, 75; hind foot, 23; ear, 13.

Zygodontomys chrysomelas (Allen).

Three specimens, Bogaba, July.

It is possible that the Chiriqui form may prove to be subspecifically different from true *Z. chrysomelas* of Costa Rica (type locality Suerre). One specimen loaned by Dr. Allen from San Carlos, differs from the Bogaba examples in being smaller, with smaller skull, lighter rostrum, and broader palatal slits. Additional material, however, may show these differences to be individual.

The Vesper rats, related to *Z. chrysomelas*, of which there are several in South America, form quite a distinct group in the genus *Zygodontomys*, differing from the more typical members, in their very dark coloration, reddish bellies, nearly naked, dusky feet and hands, with white nails, and in their wider skulls — especially wide between the orbits — with strongly marked, overhanging superciliary beading.

Measurements (of the three Bogaba skins) —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,290	♂ old ad.	240	100	27	..
10,291	♀ ad.	230	90	28	..
10,292	♂ yg. ad.	215.	90	27	14

Reithrodontomys australis Allen.

Two specimens, adult ♂ and ♀, Boquete, 4,000 feet, April 30.

These I have compared with the type of *R. australis* from Volcan de Irazú, Costa Rica, loaned by Dr. Allen. In color they exactly agree, except that the upper surface of the feet is darker, more grayish — the feet being whitish in the type. The skulls of the two Boquete specimens, are heavier throughout especially the rostral part, and in this character they are intermediate between true *R. australis* and the form described below from the summit of the Volcan de Chiriqui.

Measurements (of the two Boquete skins) —

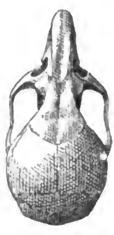
No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,282	♀ ad.	165	85	18	14
10,283	♂ ad.	155	75	19	12

Reithrodontomys australis vulcanius, subsp. nov.

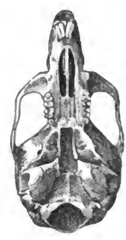
Type. — Mus. Comp. Zoöl., No. 10,281, ad. ♂, Volcan de Chiriqui, May 26, 1901. 10,300 feet.

Characters. — Pelage extremely long and silky; colors much darker and grayer than in true *R. australis*; skull heavier, especially rostral portion; palatal slits longer and wider.

Color. — Broad dorsal band strong sepia, paling off on sides to isabella color, somewhat shaded with cinnamon; top of nose and head paler, grayer than back; under parts isabella color, strongly shaded with cinnamon between arms and about vent; feet and hands grayish; ears well haired, sepia (about the same shade as darker parts of back); tail well clothed with short, close hairs dusky above, grayish below.



16. × 1¾



17. × 1¾

Figs. 16 and 17. *Reithrodontomys australis vulcanius.* Type.

Measurements. — Type, adult ♂, total length, 170; tail vertebræ, 95; hind foot, 19; ear, 14. Skull, basal length, 19.4; occipitonasal length, 22.8; zygomatic width, 11.4; mastoid width, 11; interorbital width, 3.4; length of nasals, 8.2; width of nasals, 2.6; length of palate to palatal notch, 9.2; length of palatal slits, 5; width of palatal slits, 1.8; upper molar series, 3.2; length of single half of mandible, 11.4.

Remarks. — *R. australis vulcanius* is a well marked alpine form, very different from true *R. australis* in color, and also in its exceedingly long, silky pelage. The skull is slightly different.

Reithrodontomys costaricensis Allen.

Thirty specimens, Boquete, 4,000 to 6,000 feet, January, February, April, and June.

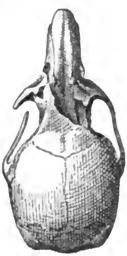
I have compared this series with specimens from the type locality — La Carpintera, Costa Rica — loaned by Dr. Allen, and cannot find that the Chiriqui animal is at all different. They vary a good deal individually in color, ranging from strong brownish orange rufous, without darker dorsal band to raw umber with darker dorsal band: below the color ranges from white to dull fulvous. Young individuals are always darker and duller than adults.

R. costaricensis was one of the commoner small mammals of the forest belt of the Volcan de Chiriqui.

Reithrodontomys creper,[1] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,284 ad. ♀ Volcan de Chiriqui, June 2, 1901. 11,000 feet.

Characters. — Belonging to a peculiar group of large-sized species with curious bird-like skulls, — very long slender rostrum and large round brain case. Pelage exceedingly long, dense, and silky; colors all very dark; hind foot very



18. × $1\frac{3}{4}$.

19. × $1\frac{3}{4}$.

Figs. 18 and 19. *Reithrodontomys creper.* Type.

large; tail, long. (Dr. Merriam has lately described several species of this group from Mexico. These should properly, I think, have a subgeneric name. None of them, however, are closely related specifically to the present one.)

Color. — Upper parts, middle of back, bistre, shading on sides to raw umber; face rather more dusky, especially about eyes and at base of whiskers; under parts dark cinnamon, without marked line of demarcation, but shading grad-

[1] *Creper*, dusky, dark.

ually into color of sides; toes and fingers, whitish; upper surface of feet and hands, brownish; ears, dusky; tail, dusky all round for two thirds of its length, white all around for the terminal third.

Measurements. — Type, adult ♀, with unworn teeth, total length, 215; tail vertebræ, 130; hind foot, 23; ear, 15. Skull, basal length, 21.4; occipito-nasal length, 25.4; mastoid width, 11.6; length of nasals, 8.8; length of palate to palatal notch, 10; length of palatal slits, 4.8; upper molar series, 4.2; single half of mandible, 13.6.

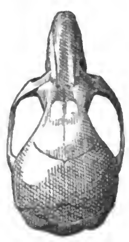
Remarks. — The type and only specimen of this remarkable little animal, is an adult ♀, but with unworn teeth, so probably it is not full grown, and old adults would be still larger. Externally it bears a somewhat superficial resemblance to the woolly Oryzomys, of the subgenus Erioryzomys. The single specimen was caught on the cold, barren summit of the Volcan de Chiriqui.

Akodon teguina apricus,[1] subsp. nov.

Type. — Mus. Comp. Zoöl., No. 10,236, old ad. ♀, Boquete, February 24, 1901. 4000 feet.

Five specimens, Boquete, 4,000 to 5,000 feet, February and April.

Characters. — Colors not so black as in true *A. teguina* (the rump and thighs in true *A. teguina* are blackish, in the new form they are scarcely darker than



20. × 1¾.

21. × 1¾.

FIGS. 20 AND 21. *Akodon teguina apricus.* Type.

the rest of the upper parts); tail, longer; ears, larger; skull, heavier; rostrum, heavier; molar-form teeth much heavier; tooth rows not so parallel, — much more divergent anteriorly. Pelage, short, close, and fine with decided gloss.

Color. — Upper parts vandyke-brown, slightly more dusky on top of head and along middle of back; under parts dull cinnamon rufous; hands, feet, ears, and tail blackish.

[1] *Apricus*, exposed to the sun, hence, southern.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,236 type	♀ old ad.	142	58	18	13
10,235	♀ old ad.	140	55	18	13
10,237	♀ old ad.[1]	140	55	18	13
10,234	♂ old ad.[1]	125	50	18	13
10,238	♀ ad.	125	55	18	13

Skull, type, old ad. ♀, basal length, 20.2; occipitonasal length, 23; zygomatic width, 12; mastoid width, 10.8; interorbital width, 4.6; length of nasals, 9; width of nasals, 2.8; length of palate, to palatal notch, 9.6; upper molar series, 4; length of single half of mandible, 12.8.

Remarks. — Through the kindness of Dr. Merriam I was able to compare the series taken by Mr. Brown with a fine adult ♂, No. 76,353, of true *A. teguina* taken by Mr. E. W. Nelson at Ocuilapa, Chiapas, Mexico. This comparison showed that the Chiriqui animal is quite distinct — though it is perhaps better to regard it as a subspecies.

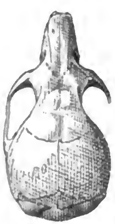
Mr. Brown caught all five of these curious dark brown little creatures, in open rocky places.

Akodon xerampelinus,[2] sp. nov.

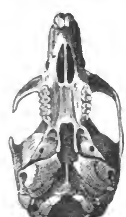
Type. — Mus. Comp. Zoöl., No. 10,240, old ad. ♂, Volcan de Chiriqui, May 26, 1901. 10,300 feet.

Three specimens, Volcan de Chiriqui, 10,300 feet. May and June.

Characters. — Apparently specifically distinct from *A. teguina*. Size of that



22. $\times 1\frac{3}{4}$.



23. $\times 1\frac{3}{4}$.

FIGS. 22 AND 23. *Akodon xerampelinus.* Type.

species; tail, longer; pelage very long and fluffy with but little lustre; colors, paler — more yellowish, less reddish brown; under parts grayish (strong cin-

[1] Teeth much worn.

[2] *Xerampelinus*, of the color of dry vine leaves.

namon rufous in *A. teguina*); skull lighter and more delicate; rostrum lighter; nasals narrower; palatal slits rather wider; audital bullae slightly larger; molar-form teeth heavier — wider.

Color. — Upper parts uniform dark yellowish brown (a color that might, perhaps be called tawny burnt-umber) under parts, broccoli-brown; hands, feet, tail, and ears, blackish (slightly grayer, less intense black than these parts in *A. teguina apricus*; due to greater hairiness).

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,240 type	♂ old ad.	145	65	17	14
10,239	♂ ad.	140	65	17	13
10,241	♂ yg. ad.	127	56	18	13

Skull. ♂ old ad. type, basal length, 19.2; occipitonasal length, 22.6; zygomatic width, 11.6; mastoid width, 10.8; interorbital width, 4.2; length of nasals, 8.6; width of nasals, 2.6; length of palate, to palatal notch, 9.6; upper molar series, 4; length of single half of mandible, 13.

Remarks. — The little Akodon of the summit of Volcan de Chiriqui is very different from the one found at lower altitudes and is entitled to full specific rank. The three examples were taken on the desolate top of the Volcano, a little below actual timber line, but still where the forest had become stunted and sparse. Like *A. teguina apricus* they were found in open rocky country.

Macrogeomys cavator,[1] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,381, old ad. ♂, Boquete, Mar. 9, 1901. 4,800 feet.

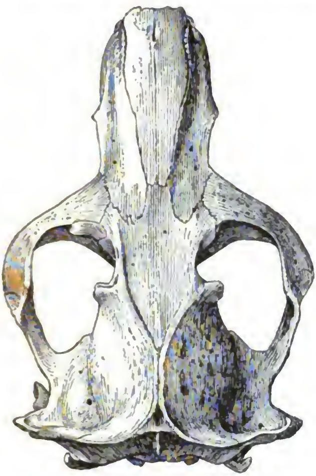
Twenty-six specimens, both sexes, Boquete, 4,000 to 7,000 feet. February, March, and April.

Characters. — Differs from the four known Costa Rican species, though nearest *M. dolichocephalus* Merriam. Compared with the type of that species, the skull is shorter and wider across zygoma; nasals, longer; distance from postorbital process to back of zygomatic arch, shorter; audital bullæ, flatter; sagittal and lambdoidal crests, heavier; zygomatic arch heavier and more angulated, standing widely and squarely out from skull. Color, very dark and nearly uniform — not pied as in the other species. Pelage, short, close, and rather harsh.

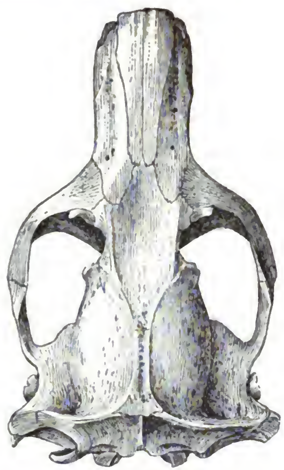
Color. — Upper parts dark seal-brown — almost black; under parts similar but slightly grizzled, the pelage sparse, so that the skin shows through; a small white anal patch, and sometimes small white patches under chin and on under side of wrists; whiskers colorless; feet, hands, and tail, naked — in dried skin yellowish brown to dusky, the end of the tail black. In many

[1] *Cavator*, one who hollows out or excavates.

specimens there are longer hairs scattered through the pelage, some of which are silvery, others brown like the general color of the back.



24. × 1¼.



25. × 1¼.

FIG. 24. *Macrogeomys cavator.* Type, old ♂.
FIG. 25. *Macrogeomys cavator.* Topotype, old ♀. No. 10,389.

Measurements (twelve adults) —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,370	♂ old ad.	410	118	54	8
10,378	♂ old ad.	390	125	53	8
10,392	♂ old ad.	390	110	50	7
10,371	♂ old ad.	385	118	51	7
10,381 type	♂ old ad.	375	120	52	8
10,385	♂ yg. ad.	360	110	47	8
10,380	♀ old ad.	400	108	50	7
10,392	♀ old ad.	390	110	50	7
10,389	♀ old ad.	380	110	49	8
10,376	♀ old ad.	375	115	52	7
10,375	♀ yg. ad.	350	110	48	7
10,377	♀ yg. ad.	350	105	48	7

Skull, type, No. 10,381, ♂ old ad. (not quite so large as some of the very old specimens) basal length, 64; occipitonasal length, 67.8; zygomatic width, 45.8; mastoid width, 33.4; interorbital width, 11; length of nasals, 28; length of palate to palatal notch, 44.6; upper molar series, 15.4; length of single half of mandible, 51.2.

Old adult ♀, topotype, No. 10,389, basal length, 61.4; occipitonasal length, 63.4; zygomatic width, 40; mastoid width, 32; interorbital width, 10; length of nasals, 25.4; length of palate to palatal notch, 41.4; upper molar series, 15; length of single half of mandible, 48.

Remarks. — This very distinct new species, was abundant on the slopes of the volcano from 4,000 to 7,000 feet, but was not seen below 4,000 feet. It hardly needs comparison with any of the four previously known species from Costa Rica.

Macrogeomys pansa,[1] sp. nov.

Type. — Mus. Comp. Zoöl., No. 10,364, old ad. ♀, Bogaba, July 6, 1901.

Eight specimens, both sexes, Bogaba, July.

Characters. — Much smaller than the alpine, *M. cavator*; hind foot propor-

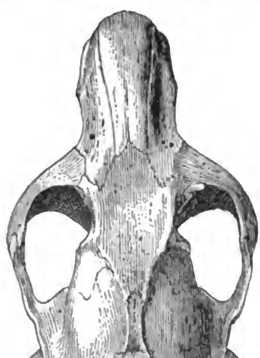


FIG. 26. *Macrogeomys pansa.* Type, old ♀. × 1½.

tionally much larger (actually nearly the same size); colors duller and browner, more grayish white on belly; pelage short, close, very sparse on under parts,

[1] *Pansa*, broad-footed.

nose and sides of head and neck where the skin shows through. Skull much smaller and weaker throughout, with less spread to zygoma; nasals, shorter; interorbital width greater; molar-form teeth much smaller.

Color. — Upper parts dull, dusky, chocolate-brown; under parts grizzled, the belly whitish: whiskers mostly colorless; feet, hands, and tail naked (in dried skin) yellowish brown, the tip of the tail dusky.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,369	♂ adult.	325	110	48	7
10,368	♂ yg. ad.	320	105	50	6
10,362	♀ old ad.	330	110	52	5
10,364 type	♀ old ad.	320	110	48	6
10,366	♀ ad.	320	100	46	7
10,363	♀ ad.	330	100	47	6
10,365	♀ yg. ad.	320	110	47	6
10,367	♂ young	300	95	47	4

Skull, type, ♀ old adult, basal length, 54; occipitonasal length, 57.6; zygomatic width, 36; mastoid width, 27.8; interorbital width, 11.8; length of nasals, 23; length of palate, to palatal notch, 37; upper molar series, 13; length of single half of mandible, 41.

Remarks. — In July, when Mr. Brown was at Bogaba, birds were moulting and mostly unfit for specimens; consequently he spent considerable time searching for suitable places for future work, trapping mammals, and collecting a few examples of some of the rarer birds. On one of his long rides he came upon a single isolated colony of pocket gophers. It was in the foot-hills, about 600 feet altitude, and was the only colony he found in the whole region. The members of this colony were rather hard to trap, as pocket gophers sometimes are, and unfortunately the only old ♂ secured was caught in the trap by the head and the skull crushed. The species is very different from the large, black species found so abundantly on the higher slopes of the Volcan de Chiriqui.

Heteromys repens,[1] sp. nov.

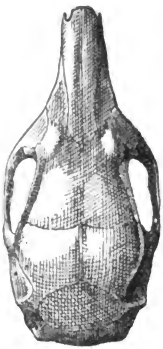
Type. — Mus. Comp. Zoöl., No. 10,356, old ad. ♀, Boquete, April 8, 1901. 4,000 feet.

Six specimens, Boquete, 4,000 to 5,800 feet, February and April.

Characters. — Apparently a very distinct species. Hind feet large, soles naked, six pads. These characters at once distinguish it from the Costa Rican *H. salvini nigrescens* Thomas. From *H. adspersus* Peters, from Panama, it differs in its longer hind feet and strong cranial characters, the skull being very much wider between the orbits; the nasals longer than the ascending branches of premaxilla (shorter in *H. adspersus*); the supraorbital beading

[1] *Repens*, unexpected, unlooked-for.

more overhanging, and not so S-shaped. From the large South American species (*H. anomalus* Thompson, *H. melanoleucus* Gray, and *H. jesupi* Allen) it can be separated by its shorter, wider skull, — much wider between orbits, and lighter rostrum.



× 1¼.

FIG. 27. *Heteromys repens.* Type.

H. longicaudatus Gray, from "Mexico," I do not know, and the description is wholly inadequate. Dr. Thomas says it belongs to this group. Possibly it may be somewhat like the present species, though if from Mexico this is improbable.

Color. — Upper parts, — top of nose and face to eyes grayish dusky; shoulders and sides finely mixed, dark, dusky, brown, and tawny ochraceous; median parts of rump and lower back darker, more dusky; no yellowish or fulvous line along lower sides; under parts, including upper lip, under side of nose, inner side of legs, and under side of arms, pure white; outer surface of legs dusky; upper surface of arms gray; feet and hands white; ears dusky, sparsely haired, with a slightly perceptible whitish border; tail thinly clothed with short, stiff hairs, dusky above, white below, and with a slight whitish pencil.

No. 10,360, young ♀, is in the slaty pelage of the very young, the whole upper parts being slaty. No. 10,361 ♀, also young, has in the middle of the back a large sized patch of hairs colored like those of the adult, the rest of the upper parts being slaty.

In No. 10,358 there are a good many wholly white spines scattered through the upper surface, and in the other three adults a very few of these white points can be seen.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,359 [1]	♂ old ad.	300	155	33	15
10,355 [1]	♂ old ad.	285	150	32	14
10,358 [1]	♂ old ad.	285	145	33	15
10,356 [1] type	♀ old ad.	282	150	33	15
10,361	♀ young	247	130	32	15
10,360	♀ young	235	115	30	12

Skull, type, ♀ old adult, basal length, 31.4; occipitonasal length, 35.4; zygomatic width, 16.4; mastoid width, 14.8; interorbital width, 9.2; length of nasals, 14.8; width of nasals, 4.2; upper molar series, 4.8; length of single half of mandible, 17.2.

Remarks. — From Peters's careful description and plate it is perfectly clear that the Chiriqui Heteromys is distinct from *H. adspersus*. It is also clear

[1] All with worn teeth.

from Dr. Thomas's description that it is not his *H. salvini nigrescens*, but what Gray's *H. longicaudatus* may be I can only conjecture. The type is extant in the British Museum, but although Dr. Thomas has stated that it is a good species, he has never given any clue to its identity. Gray's original description is so meagre that it is unfortunate that Dr. Thomas did not characterize the species when he reinstated it.

Proechimys centralis chiriquinus Thomas.

Thirty-one specimens, Divala, November and December, and Bogaba, July; those from the latter place are topotypes.

Though very common in the low lands and the foot-hills of the Volcan de Chiriqui, the spiny rat certainly does not ascend the Volcano to any great height, as Mr. Brown did not find it at Boquete.

Dasyprocta isthmica Alston.

Nine specimens, young and adults, Divala, November, Boquete, 3,500 feet, June, and Bogaba, July.

Agouti paca virgatus, subsp. nov.

Type, and only specimen. — Mus. Comp. Zoöl., No. 10,079, old ad. ♂, Divala, December 16, 1900.

Characters. — The Central American paca differs from the Brazilian form, true *A. paca* (Linn.), in being larger, with larger hind foot; in having the second stripe on the sides much less broken into spots; all the spots above the two lateral stripes smaller; the ground color of upper parts richer brown. Skull much larger; palate narrower; audital bullæ flatter.

Color. — Ground color of upper parts, walnut-brown; feet, hands, and cheeks duller, paler, and shaded with wood-brown; under parts white; on the lower sides a white stripe extending from hip to shoulder; above this another white stripe, a little shorter than the first; these two bands break up on sides of the neck and on flanks into series of white spots, which are much smaller on the flanks; above the white bands two rows of small white spots, the lower one reaching from sides of neck to flanks; the upper one very short — made up of only six or seven indistinct spots.

Measurements. — Type, old ad. ♂, total length, 740; tail vertebræ, 22; hind foot, 130; ear, 43. Skull, type, basal length, 139.6; occipitonasal length, 151; zygomatic width, 104; mastoid width, 54.8; interorbital width, 47.2; length of nasals, 51.2; width of nasals, 26; length of palate, to palatal notch, 76; width of palate at middle of second molar-form tooth, 7; at middle of last molar-form tooth, 10.2; upper molar series, 29.6; length of single half of mandible, 107.

Remarks. — I cannot find that the Central American paca has ever been named. The Museum has a large series of skulls of true *A. paca* from Brazil, and several specimens, skins and skulls, of the northern form from Costa Rica, collected by Gabb. One adult ♀ taken by Mr. Brown, at Santa Marta, Colombia, and Venezuelan examples in the United States National Museum, are apparently referable to true *A. paca*. I have not seen any specimens from Panama, but all examples from Costa Rica and Chiriqui belong to a race that is easily separable from true *A. paca* of Brazil.

The paca is said to be variable in color everywhere, light and dark individuals occurring together, but in spite of this I think the northern form averages much darker, richer brown. It certainly has the upper of the two lateral white stripes much less broken up into spots, and all the white spots much smaller. Besides these differences in color and pattern, the Central American animal is larger, with longer hind feet, and has a much larger skull, with narrower palate and flatter audital bullæ. Skulls of the paca vary a good deal individually in regard to the roughening of the upper surface. In some old skulls the upper surface is excessively roughened, while in others of about the same age it is comparatively smooth.

Lepus (Tapeti) gabbi (Allen).

Nine specimens, Divala, November and December. Boquete, 3,400 to 4,500 feet, March and April, and Bogaba, July.

The seasonal differences in color are well shown by this series. July specimens are much redder, with but few black-tipped hairs in the back, than autumnal examples.

Felis bangsi costaricensis Merriam.

One female, Boquete, 4,000 feet, April 22, the type of Dr. Merriam's new form.

Felis pardalis Linn.

One fine adult ♂, Boquete, 4,000 feet, April 10.

Conepatus[1] mapurito (Gml.).

Two specimens, ♂ and ♀ adults, Boquete, 4,000 and 4,500 feet, February and March.

[1] I am aware of the proposed change in the generic names of the skunks, but, not having reached a definite decision, use the old name.

Galera barbara biologiæ (Thomas).

One male, Bogaba, July 9. The black-headed Central American form is a very strongly marked subspecies; in addition to this specimen the Museum has skins from Costa Rica collected by Gabb.

Putorius (Ictis) affinis (Gray).

Three specimens, two adult and one young males, Boquete, 4,000 to 5,800 feet, February, March, and April. These examples agree very well with Gray's description; they vary somewhat among themselves in color; the young one, No. 10,114, has a wholly black head, the other two have small irregular (not the same on both sides) white patches, behind the eye, in front of the ear, and above the corner of the mouth. In No. 10,114, the under parts, except the chin, which is whitish in all three, are intense orange-rufous; in No. 10,112, the under parts are a paler shade of the same color; and in No. 10,113 paler still and more yellowish.

Measurements —

No.	Sex.	Total length.	Tail vert.	Hind foot.	Ear.
10,112	♂ old ad.	480	170	52	23
10,113[1]	♂ ad.	400	143	43	20
10,114	♂ young	355	125	47	20

Potos caudivolvulus (Schr.).

Three specimens, two males and a ♀, Bogaba, July. I do not think the Central American form is the same as true *P. caudivolvulus* of Surinam, but I have not sufficient material to decide the question.

Nasua narica (Linn.).

Six specimens, both sexes, Boquete, 3,800 to 5,800 feet, April and March. The nasuas separate naturally into many geographic races. These, as proper material accumulates, are gradually coming to be understood; the name *narica* is used here provisionally.

Procyon lotor hernandezii (Wagler).

One male, Pedregal, July 25.

[1] I suspect this specimen was wrongly sexed, and is an adult ♀; judged by the skull it is not much younger than No. 10,112.

Myotis nigricans (Wied).

One ♀, Bogaba, July 1.

Eptesicus fuscus miradorensis (H. Allen).

One ♂, Boquete, 4,800 feet, March 23.

Lasiurus borealis mexicanus (Saussure).

One ♂, Boquete, 4,000 feet, February 18.

Rhogeessa tumida H. Allen?

One ♂, Bogaba, July 6. Mr. Miller, to whom I submitted this specimen, is a little doubtful as to its identity with *R. tumida*, but on the strength of a single specimen preferred to so determine it.

Hemiderma brevicaudum (Wied).

Thirteen specimens, Bogaba, July. This series presents a wide range in the color of the upper parts, varying from hair-brown to russet, with every intermediate shade.

Glossophaga soricina (Pallas).

One ♀, Bogaba, July 2.

Artibeus intermedius J. A. Allen.

Three specimens, an old ♀, and youngish ♂ and ♀, Bogaba, July. The younger specimens are more sooty, with the facial stripes less well indicated and have smaller skulls, and thus agree with the young described by Dr. Allen. I must confess, however, that I was at first inclined to regard these as belonging to a different species from the old one. The difference in size is great and the skulls do not show the degree of immaturity that one would expect with the difference in size.

Vampyrops helleri Peters.

Six specimens, Bogaba, July.

Sturnira lilium (E. Geoff.).

One adult ♀, Volcan de Chiriqui, 7,500 feet, February 17, 1901.

Desmodus rotundus (E. Geoff.).

Three specimens, Bogaba, July.

Alouatta palliata (Gray).

Three specimens, adult ♂ and ♀, and a youngish ♀, Boquete, 4,000 feet, April.

Saimiri oerstedii (Reinh.).

Five specimens, both sexes, Bogaba, July.

The squirrel monkey is common in the scrubby forest of the foot-hills of the Volcan de Chiriqui. It was very tame, and Mr. Brown states that often little parties of them, would follow him about in the underbrush, chattering, and allowing him to come so near that he could almost put his hand on them. It is a beautiful creature, with a long tasselled tail, and is admirably shown in Alston's plate in the Biologia Centrali-Americana. Mr. Brown states that he never saw a creature that he disliked so to kill, and after he had secured five specimens, nothing would induce him to molest the little troupes that accompanied him on his rambles over the foot-hills.

Cebus hypoleucus (Humboldt).

Two adult females, Boquete, 4,000 feet, March, and Bogaba, July.

Bulletin of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

VOL. XXXIX. No. 3.

SOME CARBONIFEROUS CESTRACIONT AND ACANTHODIAN SHARKS.

BY C. R. EASTMAN.

WITH SEVEN PLATES.

CAMBRIDGE, MASS., U. S. A.:
PRINTED FOR THE MUSEUM.
JUNE, 1902.

No. 3. — *Some Carboniferous Cestraciont and Acanthodian Sharks.* By C. R. Eastman.

Coincident with the marked increase of Pelmatozoa and certain families of Brachiopods during the Lower Carboniferous all over the world, a race of sharks armed with crushing teeth suddenly acquired dominance, became exceedingly diversified, and finally all but passed away towards the close of the Palæozoic. Of the very extensive group represented by the Cochliodontidæ and Cestraciontidæ, which is at least as ancient as the Devonian, only one genus, the so-called Port Jackson shark, survives at the present day. With this all of the fossil forms agree in having a similar but more or less specialized dentition, in consequence of which this creature stands in the same relation to the host of Carboniferous sharks with crushing teeth that Nautilus does to fossil Cephalopods.

Some interesting specimens from the Carboniferous described in the present paper throw new light on the structure and relations of Campodus and the series of Edestus-like forms, all of which are to be regarded as members of the Cestraciontidæ. Spines belonging to the first and second dorsal fins of Ctenacanthus, from the Kinderhook limestone of the Mississippi Valley, and new species of Acanthodes from the Coal Measures of Mazon Creek, Illinois, are here illustrated and described for the first time. A list is also given of the fossil vertebrate fauna known to occur at the Mazon Creek locality, including some species not previously reported.

I. ON THE NATURE OF EDESTUS AND RELATED FORMS.

Notwithstanding the extensive literature concerning the peculiar ichthyic remains known as Edestus, Helicoprion and the like, their nature, functions, and relations are admitted by most authors to be still highly problematical. Occurring as they do singly, and always in the detached condition, these objects have been most frequently looked upon as Selachian fin-spines, although their correspondence to dental structures has been patent to nearly all writers. Perhaps the most novel conjecture as to their function is that recently advanced by Karpinsky,[1] who, as an alternative hypothesis to regarding them as caudal spines, refers the thrice-coiled spiral of Helicoprion to the snout region, and supposes it to have been a powerful weapon for attack and defence, each individual possessing but a single organ of this kind (*cf.* text-figure 1). The Russian Director's main reason for excluding these spirals from the mouth cavity, namely on account of their large size (26 cm. in diameter), is not, in the opinion of at least two of his critics, an insurmountable objection, nor can any argument for an external position be based on the presence of so-called "placoid scales" over and around the bases of the segments or teeth, when it is evident from the author's beautiful figures that he has mistaken calcified cartilage for shagreen granules.

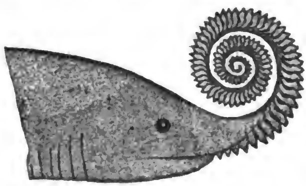


FIG. 1.

Karpinsky's conjectural restoration of *Helicoprion bessonowi*, from the Russian Permo-Carboniferous (after Karpinsky). × $\frac{1}{10}$.

In the reviews which have appeared of Dr. Karpinsky's memoir,[2] it is admitted that much evidence has been brought forward in favor of the view that Edestus and Helicoprion should be looked upon as Palæozoic sharks with sharp piercing teeth, which were never shed, but became fused into whorls as the animal grew. And quite recently it has been claimed by the present writer [3] that positive proof of the odontological nature of Edestus, Campyloprion, and Helicoprion is furnished by comparison with the dental armature of Campodus. According to this view, the curved or coiled "spines" of Edestus and Helicoprion are not dermal defences at all, but veritable teeth corresponding to the symphysial series of Protodus, Campodus, the existing Cestracion, Carcharias, Chlamydoselache and other forms, only more modified with respect to curvature. Initial stages in the coiling of symphysial or intermandibular

[1] *Karpinsky, A.*, Ueber die Reste von Edestiden, und die neue Gattung Helicoprion. Verhandl. k. russ. Mineral. Ges. St. Petersburg, Vol. XXXVI., p. 467, 1899.

[2] *Woodward, A. S.*, Helicoprion, — Spine or Tooth? Geol. Mag. (4), Vol. VII., p. 33, 1900. — *Eastman, C. R.*, Karpinsky's Genus Helicoprion: a Review. Amer. Nat., Vol. XXXIV., p. 579, 1900.

[3] Science, n. s., Vol. XIV. (1901), p. 795. — Geol. Mag. (4), Vol. IX. (1902), p. 148.

teeth are displayed by numerous diverse forms, such as Protodus, Glossodus, Sandalodus, Cochliodus, Periplectrodus, Onychodus and other Palæozoic fishes. Amongst these the type-specimen of "*Helodus coxanus*" Newberry, which is in reality the symphysial series of *Cochliodus latus*, exhibits only a slight inrollment, and is hence indicative of a primitive stage. A more advanced stage is represented in another family by the corresponding series of *Campodus variabilis* and the various species of Edestus. Campyloprion, as the name indicates, is a more arcuate form and possesses more numerous segments; and finally, in the completely coiled Helicoprion, we observe the most extreme specialization in this direction.

Campodus.

(Plates 1-3.)

The best account of the dentition of this genus is that given by Max Lohest [1] in 1883, who pointed out the close similarity between it and the living Cestracion (*Heterodontus*), and corrected certain errors in the earlier restorations of St. John and Worthen.[2] The observations of all these writers were based upon a unique specimen from the Missourian of Osage County, Kansas, referred by them to the left ramus of the lower jaw, and comprising upward of 450 teeth arranged in eighteen transverse rows. This specimen was deficient at its anterior extremity, where the individual teeth are greatly diminished in size: and no information was afforded respecting the nature of the union of this ramus with its fellow, or the presence or absence of symphysial teeth. The gape of the mouth being thus entirely conjectural, the jaws were restored by St. John and Worthen after the fashion of Raja, with the forward ends apposed to one another in a nearly straight line; and inferentially the structure of Campodus was supposed by them to have conformed to the type of modern rays.

Were there a reasonable basis for this view, it would be of some moment in considering the question of the origin of rays. For although the Batoid type is regarded as a comparatively modern derivative, not antedating the Jurassic so far as known, nevertheless we cannot deny the existence at even so remote a period as the Devonian of offshoots from the primitive Elasmobranch stem, which approximated the modern ray type in certain notable respects. That such early approxi-

[1] *Lohest, M.*, Recherches sur les poissons des terrains paléozoiques de Belgique. Ann. Soc. Géol. Belg., Vol. XI., p. 314, 1883.

[2] *St. John, O.*, and *Worthen, A. H.*, Pal. Illinois, Vol. VI., p. 318, Pl. VIII., 1875.

mations to typical rays as Tamiobatis, Archæobatis, Psammodus, Janassa, etc., are genetically related to the Batoidei, as commonly recognized, may perhaps be questioned, and indeed is even denied by Dr. O. P. Hay,[1] since we should expect to find greater differences than obtain between modern sharks and rays, had their divergence taken place at an extremely remote period. There is no difficulty in supposing the dentition, general configuration of the body, and most minor characters of rays to have been paralleled in the Palæozoic by adaptation to similar conditions, such as bottom-living, amongst specialized groups which later became extinct; and we are obliged to affirm that at present there is no evidence to show that the essential feature of rays, namely the attachment of fin-supports to the side of the head, was originated until well along in the Mesozoic.

But with respect to Campodus, we may dismiss the question of its supposed affinities to rays on the ground that all available evidence points to a close relationship to Cestracion, the arrangement of teeth being essentially similar, and the mouth-cleft long and narrow, instead of wide and transverse. The two rami of either jaw probably included about the same angle between them as in Cestracion. Orodus and related Palæozoic genera undoubtedly possessed a Campodus-like dentition; and while these, together with more specialized forms such as Edestus, etc., failed to survive the Palæozoic, the primitive Cestraciont type manifested great longevity.

The lateral series of teeth belonging to Campodus are already sufficiently well known, thus rendering further description superfluous. We need only remark that the orientation of detached teeth may be readily determined from the following characters: (1) The coronal buttresses are invariably directed outward, and the longitudinal ridge on the oral surface is slightly ectad of the middle line of the crown; (2) the antero-lateral and postero-lateral series increase in size on passing toward the middle of each ramus, where one of the series is sensibly enlarged; (3) the coronal eminences are more elevated in one jaw, presumably the lower, than in the other; (4) interposed between the foremost of the antero-lateral series on either side are the most anterior, or as we shall hereafter term them, symphysial teeth, immediately to be described.

Symphysial dentition. — There are at present but two specimens known of the symphysial dentition, both of which are illustrated in the accompanying figures, which are reproduced from photographs. That shown in

[1] *Hay, O. P.*, The Chronological Distribution of the Elasmobranchs. Trans. Amer. Phil. Soc., Vol. XX., p. 74, 1901.

Plates **2** and **3** was obtained a number of years ago by Mr. G. C. Merrill from the Upper Coal Measures of Osage County, Kansas, and is preserved in the Museum of Comparative Zoölogy at Cambridge (Cat. No. 749). The second example, shown in Plate **1**, was derived from the Upper Coal Measures of Cedar Creek, Nebraska, and belongs to the Museum of the Nebraska State University at Lincoln. To Professor Edwin H. Barbour, Director of the University Geological Survey of Nebraska, the writer is greatly indebted for the privilege of studying and describing this and numerous other Carboniferous fish remains which have been collected during the prosecution of the Survey. Acknowledgments are also due to Miss Carrie A. Barbour, of Lincoln, through whose skill and zeal these specimens have been beautifully prepared or otherwise rendered available for study.

It is stated by Professor Barbour that when his specimen of the symphysial dentition of Campodus was discovered, it was in almost perfect condition, and the slight injury it sustained on being extricated from the matrix was subsequently repaired by his sister. For instance, a number of the coronal buttresses on one side, and several of the coronal apices were broken off; such of these as could not be mended from the original fragments are now restored in plaster. As seen in Plate **1**, the two posterior coronal apices, and also the fourth and fifth counting from the proximal end, are partly restored; the remainder are in their original condition. Weathering has removed most of the enamel from this specimen, and indications of wear during life are not readily discernible.

The Nebraska specimen is important from the fact that it first led to an adequate understanding of the earlier known Kansas example, which in turn disclosed a wealth of information respecting ancient types of Cestraciont dentition, and furnished the solution of a number of debated problems. For in the state in which the Kansas dentition originally came to the Harvard Museum, all of the coronal apices having been broken away, the complete form of the symphysial teeth was not revealed, and their relations to Edestus were unsuspected. That this specimen long ago challenged the attention of palæichthyologists, although no record of their views concerning it has come to light, is witnessed by the fact that plaster casts were taken from it at the direction of Mr. Orestes St. John, while he was Assistant in Palæontology at the Museum under Professor Agassiz. Some of these replica, together with casts of the lateral series described by St John and Worthen in 1875, have since found their way into other collections.

From this statement regarding the history and condition of these two examples of symphysial dentition, we may pass on to their detailed description; and as they fortunately supplement each other, and occupied without doubt the same position in the mouths of two precisely similar individuals, it will be more convenient to consider them together instead of separately. In the first place, however, we must conceive of the dentition of Campodus having been developed as follows: as the newly formed successional teeth were pushed up from the supporting cartilage, they were carried forward in regular order, gradually increasing in size with the age of the individual, while the functional teeth which they replaced were not shed, but became rotated over on to the outer side of the jaws. Everywhere, except in front, the unrolling of these series proceeded in a more or less spiral fashion, after the manner of Cestracion. And as in this recent genus, also, the symphysial series were bilaterally symmetrical and coiled in a single plane. The number of symphysial teeth, and curvature of the series, is practically the same in both genera.

It is interesting to note in this connection, that a relic of ancestral conditions still persists in Cestracion, in that occasionally the median azygous series of the lower jaw is somewhat enlarged, while opposed to it in the upper jaw, two corresponding series, one on either side, are also slightly enlarged. Chlamydoselache and some other recent sharks possess a median azygous series in the lower jaw, opposed to which is a paired series in the upper. The selfsame arrangement is very conspicuous in Campodus, where the two examples before us obviously represent the unpaired median series, and, as shown by marks of wear, played against a corresponding paired series in the opposite jaw. These two corresponding series were, however, separated by an interval, so as to include the azygous series for a greater part of its width between them when the jaws were closed. So far as we may depend on analogy, the conclusion is warranted that the two specimens of symphysial dentition before us pertain to the lower jaw, and that examples of paired series belonging to the upper jaw have not as yet been encountered.

Two facts deserve to be specially noted, for reasons which will at once present themselves. In the first place we observe that the symphysial dentition of Campodus is bilaterally symmetrical and curved or inrolled in a single plane. And, secondly, the symphysial teeth are very disproportionately enlarged with respect to the antero-lateral series, the disparity being in fact greater than is known to occur in any other genus, recent or fossil.

Now, with respect to inrollment or coiling, we need only repeat that this character pervades numerous sharks, both those with piercing and those with crushing teeth. Indeed, some forms are known, such as Cochliodus, Psephodus, etc., which have posterior dental plates adapted for crushing, and feebly prehensile symphysial teeth (*e. g.*, "*Helodus coxanus*" Newberry). In Campodus the anterior series are only moderately arched, and the individual teeth scarcely override one another. But in Edestus, Campyloprion, and Helicoprion, not only is the coiling carried to a remarkable degree, but the teeth are angulated so that their bases either override or ensheathe one another.

Respecting the disproportionate enlargement of the symphysial as compared with adjacent antero-lateral series, this condition appears to have been peculiar to Palæozoic Cestracionts. We can almost certainly predicate its existence in Orodus, owing to the close similarity of its teeth to those of Campodus. And although the lateral dentition of Protodus, Edestus, Campyloprion, and Helicoprion has not yet been identified as such, nevertheless it follows from our interpretation of this class of remains that transverse rows of smaller teeth were present along the sides of each ramus of the jaws. An understanding of Campodus having once enlightened us as to the disparity between the symphysial and lateral series of early Cestracionts, we are enabled to avoid the rather formidable conception of giant sharks in the Carboniferous, armed each with a mouthful of Edestus-like or completely coiled spirals, since there is no evidence to show that Edestus, Campyloprion, or Helicoprion possessed more than one series, and this is to be relegated to the median line in front. Absence of marks of wear in the symphysial teeth of the three last-named genera, together with the difficulty of accommodating a paired series larger than that of Campodus in the upper jaw, favor the hypothesis that each individual possessed but a single arch, which was located presumably in the lower jaw. Although corresponding in position to the intermandibular arch of Onychodus, and to the presymphysial bone of Saurodon and Saurocephalus, it is obvious that no homology exists, as has already been shown by Newberry and others in commenting on Miss Hitchcock's interpretation.[1]

That the office of the symphysial dentition of Campodus was chiefly

[1] Ann. N. Y., Acad. Sci., Vol. IV. (1888), p. 118. Since the discovery of Helicoprion by Karpinsky and its reference by him to the snout region of an Elasmobranch, Jaekel has sought to revive Miss Hitchcock's original interpretation of Edestus, regarding these structures "als Stossorgane, die aus dem Unterkiefer vorgestreckt waren." Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 297.

masticatory is proved by the deeply worn facettes along the lateral surface of the crowns on either side. These marks of contact with an opposed paired series are most conspicuous on the first four or five teeth counting from the front, indicating that these remained functional for a considerable period, while those following were just beginning to come into play. From the fact that the front face of the smaller anterior tooth is deeply worn, it is clear that the series has been preserved intact in this direction ever since the creature was alive, and this polished front face cannot be accounted for except as caused by abrasion against hard foreign objects, such as sharks of bottom-feeding habits might encounter. It appears practically certain that the eleven teeth which are still preserved in the Nebraska specimen, and thirteen in the Kansan, *were altogether retained within the mouth cavities* of their respective owners, and did not protrude relatively further forward than do the anterior series of the modern Cestracion.

The considerations which uphold the views just stated are as follows: (1) In the Kansan specimen the supporting cartilage to which the individual teeth are attached, and which forms part of the symphysis itself, is continued so far as the anterior (distal) tooth, which at the same time is the most worn of the series; (2) in addition, the cartilage referred to is studded with numerous small "teeth," or more properly speaking, irregular enamel-covered bosses, tubercles, or patches of dentine.[1] These would not be present along the bases of the median series if the latter had projected freely beyond the mouth region; (3) if the worn anterior portion of the arch had become so far displaced by successional teeth as to have protruded from the mouth, those teeth which in their turn became functional would exhibit prominent indications of wear; whereas, in fact all behind the first four or five are but slightly abraded.

The worn facettes along the sides of the anterior, or as they may properly be termed, functional teeth, are not plane, but slightly concave; and each tooth is bevelled at a slightly independent angle from the rest. The enamel has of course been entirely worn through, so that the underlying dentine tubules are displayed in section. The enamelled prominences which have been referred to as flanking the lateral extremities of the median series have their oral surfaces likewise abraded. Although the enamel is not preserved on any of the coronal apices of

[1] Similar bodies are figured by St. John and Worthen in connection with the lateral series, and interpreted by them as "placoid scales." Pal. Ill., Vol. VI. (1875), p. 315.

the median series, it is considered remarkable that the apices themselves, which are sharp-edged and non-blunted, should be comparatively unworn. Biting as they did between the inner faces of the paired series of the opposite jaw, they would have become very obtuse had the creature's fare consisted of hard-shelled prey, such as mollusks or echinoderms. This leads to the inference that Campodus and its congeners were sharks which subsisted chiefly on vegetation which flourished in the Carboniferous lagoons, or else upon soft animal prey.

The coronal eminences of the median series in Campodus rise vertically above the rest of the tooth in the middle line, and are but slightly compressed from side to side. The anterior and posterior edges are prominent, and although faint wrinkles occasionally appear, the edges are not serrated, in which respect they differ from Edestus and more specialized forms. In two other directions is Campodus less specialized than the Edestus-type: the symphysial teeth are, in their entirety, but little laterally compressed; and, secondly, although their crowns are inclined forward at a steep angle, they do not override one another, and their roots are not produced.

Antero-lateral series. — We come now to a consideration of perhaps the most important feature displayed by the Kansas example, and that is the natural association of the symphysial with three of the antero-lateral series belonging to either side of the jaw. If, after all that has been said, any doubt remained whether the principal series were truly median and anterior in position, it would be dispelled by a mere inspection of the smaller associated series. It is evident at a glance that the latter are scarcely at all displaced with reference to the median series, except in so far as the cartilaginous rami of the lower jaw have been pressed together prior to fossilization, and hence partly close over the median series behind. The continuity of the calcified cartilage, which supports not only the median but also the antero-lateral series on either side, positively identifies this as the symphysial region. Let the paired antero-lateral series with their supporting cartilage be imagined as opened out horizontally on either hand so as to include about the same angle between them as the jaws of Cestracion, and let these series be continued behind by 18 or more transverse rows of lateral teeth, we shall then have an adequate presentment of the lower dentition of Campodus.

The antero-lateral series on the right-hand side of the symphysial are more perfectly preserved than those on the left, and are identical in all respects with the teeth occupying a corresponding position in the splendid specimen of St. John and Worthen. Twelve teeth are now visible in the foremost row on the right-hand side of the Cambridge specimen; 13 are to be seen in the second row; and of the third row, which has been fractured across, and hence appears only in section, only 6 remain. The largest tooth in the foremost of the antero-lateral series has a length of 2.1 cm.; the largest in the second row, 3 cm. Other measurements that may be conveniently recorded here are as follows: A straight line drawn from the apex of the posterior to the anterior symphysial tooth in the Kansas specimen measures 20 cm.; and a line joining the terminal apices of the Nebraska specimen has a length of 16.5 cm. The maximum width of the symphysial series is 6 cm. in the former example, and 6.2 cm. in the latter. The conformation of the individual teeth being sufficiently evident from the figures and cross-sections, further description here is superfluous. The cross-section shown in text-figure 2 is taken through the fourth tooth from the front in the Kansan specimen, except that the vertical thickness in the median line is estimated from the most anterior tooth, which is the only one displaying this dimension. In the Nebraska specimen the vasodentine of the roots is largely decomposed.

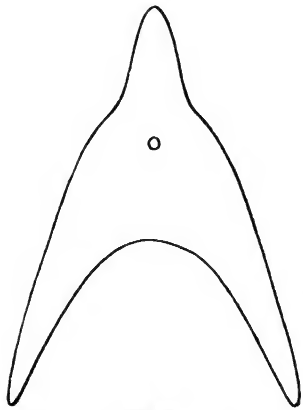


FIG. 2.

Campodus variabilis (N. & W.). Missourian; Osage County, Kansas. Generalized cross-section of a symphysial tooth. × ⅔.

Campyloprion.

(Plate 4.)

This genus was established for the reception of certain forms occupying an intermediate position between Edestus *s. s.* and Helicoprion. The latter genus is known at present only by the type species, ***H. bessonowi*** Karpinsky, from the Permo-Carboniferous of Russia. Edestus in its restricted sense comprises four species from the Coal Measures of America, *E. heinrichi*,[1] *E. minor*, *E. giganteus*, and *E. vorax*, — the last-named being the type; and a doubtful one from the European Carboniferous, — *E. carbonarius* (Germar). *E. minor* and *E. heinrichi* also occur in the Russian Carboniferous, the latter having been described by Trautschold both as a distinct genus and species. Campyloprion includes three species, two of which, *C. davisii*[2] and *C. lecontei*[3] were originally referred to Edestus, and the third, *C. annectans*,[4] is taken as the type. It need scarcely be remarked that all of the species here enumerated are known only by their symphysial dentition; many are founded on unique specimens, and the majority are in a more or less fragmentary state of preservation. Nevertheless these forms taken together constitute a remarkable series, in which the progress of evolution is readily traceable. They signalize themselves as a group of Cestracionts, which early established the habit of retaining their worn symphysial teeth instead of shedding them. Later on, as these teeth became enlarged through specialization in various genera, the difficulty of accommodating them without their proving an encumbrance to the creature was overcome by the simple device of coiling, — the same mechanical contrivance which had already been carried to a remarkable perfection amongst Nautiloids, and was never afterwards abandoned amongst Ammonites except with disastrous or fatal results. In this parallelism between the coils of Helicoprion and involute Cephalopods we observe the culmination of efforts expended along a certain direction, the design being to accommodate a large number of segments in a minimum of space and at the same time to provide for a maximum rigidity.

It remains for us now to describe the type-specimen of *Campyloprion annectans*, shown of two-thirds the natural size in Plate 4. The original was first brought to the writer's attention by his friend Dr. J. S. Kingsley, of Tufts College, in whose custody it has been for many years. There is unfortunately no record of its history beyond the fact that it was originally obtained for the Tufts Museum by the late Professor J. P. Marshall; but as to either horizon or locality from which it was derived we are without information. No one can reasonably suppose, however, that the age of the fossil antedates the Coal Measures, or is younger than Permo-

[1] The commonly accepted orthography "*E. heinrichsi*," is incorrect. Other instances of misspelled specific titles are *Cladodus hertzeri* and *Dinichthys hertzeri* instead of *C.* and *D. herzeri* respectively.

[2] *Woodward H.*, Geol. Mag. (3), Vol. III. (1886), p. 1, Pl. i.

[3] *Dean, B.*, Trans. N. Y. Acad. Sci., Vol. XVI. (1897), p. 62, Pl. iv.

[4] *Eastman, C. R.*, Geol. Mag. (4), Vol. IX. (1902), p. 151.

Carboniferous. Its color is grayish yellow, not unlike that of Campodus and other fossils from the Missourian series of this country; but on the other hand the individual teeth undeniably approach Helicoprion in form, and hence are suggestive of a corresponding horizon.

Why, then, if the teeth are of similar form, should not the specimen be referred directly to Helicoprion? The answer is that such a course would be objectionable for several reasons. In the first place the complete symphysial dentition of the latter genus consists of approximately three and one-half whorls, the largest known example measuring 26 cm. in diameter, and comprising upwards of 150 teeth. There is no evidence to show that the present series of twenty or more teeth was ever coiled into a complete spiral, any more than was the case with *C. davisii*, for instance; and certainly no marks of contact with a preceding inner whorl are visible along the base. Secondly, the occurrence of irregular patches of enamel-covered dentine along the base of the series recalls conditions we have already become familiar with in Campodus, and suggests that the arch was supported directly by cartilage as in that genus, and not spirally inrolled. Furthermore, if we assume this to be only a fragment of a complete volution, and that the inner whorls have been broken away, we shall find on continuing the indicated curvature that the diameter of the complete spiral exceeds that of the largest known example of Helicoprion, while at the same time the individual teeth are proportionally smaller, which is contrary to what we should expect them to be. This statement can be readily verified by a comparison of the accompanying illustration with the figures given by Karpinsky, especially text-figure no. 47, opposite page 426 of his memoir. And finally, we note there are no lateral grooves extending along the series near the base, as in the Russian genus. There would thus appear to be ample justification for placing the present example, and also the type of *Edestus davisii*, which was included by Karpinsky with Helicoprion, in a separate genus as we have done.[1]

It is to be regretted that the fossil under discussion should have been

[1] It is evident that *C. lecontei* belongs in the neighborhood of *C. annectans* and *C. davisii*, rather than with Edestus, owing to its more strongly arched condition and greater number of segments. Although the form of the anterior teeth is obscured by faulty preservation, they apparently had the same general configuration as the rest, and the base is longitudinally channelled. For an opportunity to examine the type-specimen of the Nevada form, the writer is indebted to the kindness of his friend, Dr. J. C. Merriam, of California State University. The type of *Edestus minor* is preserved in the Cabinet of Amherst College, and that of *E. heinrichi* in the Illinois State University at Urbana.

injured considerably by weathering and other destructive agencies. In all, portions of about 20 fused teeth are preserved, but only four of this number still remain in their entirety or nearly so. These occur near the distal end, and have been utilized for the construction of the adjoining text-figures nos. 3 and 4, which may be instructively compared with Karpinsky's text-figures nos. 23–34, or with Dr. Henry Woodward's illustrations of *C. davisii.* The teeth are much laterally compressed, closely apposed, and their lower portions are curved forward in such manner as to override one another. The latter character is more pronounced than in Campodus, less so than in Edestus and other species of Campyloprion. That the angulation or curvature of the teeth is toward the front instead of posteriorly, is demonstrated from the arrangement known to obtain in Campodus and Helicoprion. A forward inflection is attributable to *Campyloprion davisii* and *C. lecontei*, where the smallest teeth of the series are unquestionably the oldest; and it is unlikely that the segments of *C. annectans* were reflected in the contrary direction.

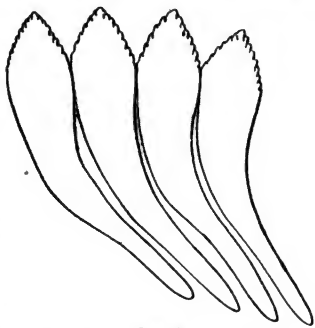


FIG. 3.

Campyloprion annectans Eastm. Lateral aspect of four of the anterior symphysial teeth, their serrated apices partly restored. × ⅔.

The whole of the lateral surface of the crown appears to have been covered with enamel, but this has been removed in most places subsequent to fossilization. In like manner the curiously curved patches of dentine occurring along the sides of the principal series toward the base have been largely denuded of their enamelled coating. Some of the symphysial teeth are worn, especially toward the proximal (posterior) end, but hardly to such an extent as to suggest attrition against mutually interlocking series of the opposite jaw. The coronal outlines are everywhere smooth and regular, except along the apical margin, which appears to have been coarsely serrated. This serration is best indicated on the opposite side of the series from that shown in the photograph, and is represented somewhat diagrammatically in text-figure 3. Making due allowance for wear, it will still be observed that the coronal apices differ from those of Helicoprion in that they are more obtuse, more coarsely serrated, and the posterior margin is not more steeply inclined than the anterior (*cf.* Karpinsky's text-figure no. 66). A line passing through the apex of a given tooth and dividing the crown into halves will intersect the base of the second tooth behind. Such a line dropped from the apex of the seventh tooth from the distal end, which happens at the

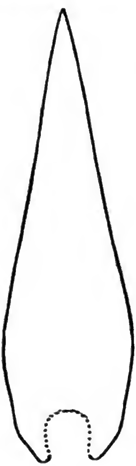


FIG. 4.

Campyloprion annectans Eastm.
Transverse section. × $\frac{9}{10}$.

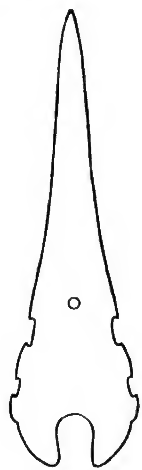


FIG. 5.

Helicoprion bessonowi Karp.
Transverse section. × $\frac{4}{5}$.

same time to be the largest to the point of intersection, measures 8 cm. It is along this line that the cross-section given in text-figure 4 is taken, where the total height is 9.5 cm, and the maximum width 3 cm. The extreme length of the specimen, measured in a straight line from end to end, is 23 cm.

Reference has already been made to the series of protuberances flanking the lower extremities of the principal teeth. That these are of the same nature as dental structures is obvious, and the corresponding bodies in Campodus may to all intents and purposes be considered as teeth, which probably formed a mosaic-like pavement. It would appear very doubtful, however, if these outgrowths of dentine in the present specimen ever functioned as teeth, although they may have served as a sort of cingulum; and their origin is probably attributable to an excessive supply of dentine-forming material, which was deposited adjacent to the larger series. That they are closely related to the principal teeth is evident from the fact that they partake of the same curvature toward the front as these. One of the distinguishing characters of Karpinsky's genus consists in the presence of a double groove extending along the lateral faces of the crown near the base. Nothing of this nature appears in the present example, nor in either of the other species of Campyloprion.

The last point we have to consider is the base, by which is meant the mass of vasodentine that served as a common support for the series. Just as the teeth are fused into a continuous series, and their extremities pass by insensible gradations into a common base, so the latter may be said to correspond, in part, at least, to fused roots. We say "fused," for the reason that no traces of segmentation are visible: a condition which is also true of Helicoprion, but not of Edestus, although in the latter genus the basal segments are sometimes obscure. As in the other species of Campyloprion, and also in the completely coiled genus, the base is channelled below by a longitudinal canal of considerable size. The dimensions and form of cross-section of this channel appear to have been about the same as in *C. davisii* and *Helicoprion bessonowi*, although comparisons are difficult, owing to mechanical compression and partial removal of the lateral walls. Longitudinal striæ extending along the base, and also a generally perforated appearance, such as are here in evidence, are characters not uncommonly presented by the roots of sharks' teeth, and are correlated with the attachment of the series in the supporting symphysial cartilage. The enormously developed basal segments (roots) of Edestus exhibit a more vascular structure than the compact vasodentine base of Campyloprion.

Comparison of Genera possessing an Edestus-like form of Dentition.

The principal characters of the four genera of Cestraciont sharks whose dentition has been described in the preceding pages, may be summarized as follows:

Campodus. — Symphysial dentition consisting of a median azygous arched series of fused teeth in one jaw, presumably the lower, opposed to which in (presumably) the upper is a paired series of similar teeth slightly separated from each other and interlocking with the first. These series consist of at least thirteen greatly enlarged teeth which are but little laterally compressed, whose coronal buttresses are directed anteriorly (ectad), and whose crowns are inclined in the same direction, but without being bent so as to override one another. Coronal apices very stout and prominent, rather obtuse, their anterior and posterior margins sharp and smooth, or but faintly wrinkled. Lateral dentition consisting of about 18 transverse series of Orodus-like teeth, arranged after the same general pattern as in Cestracion. Spines and scales unknown. Carboniferous. Type, *C. agassizianus* de Koninck.

Edestus. — Symphysial dentition consisting of a moderately arched series of fused teeth, which are fewer in number (5–8) than in the preceding genus, and more laterally compressed. The segments are bent forward in such manner that the base of each tooth ensheathes those lying next in front. Coronal apices prominent, usually acuminate, and with coarsely serrated anterior and posterior margins, the latter more steeply inclined than the former. Remainder of crown (portion corresponding to the lateral extensions of Campodus) greatly reduced. Lateral series and other parts of the skeleton unknown. Coal Measures. Type, *E. vorax* Leidy.

Campyloprion. — Symphysial dentition consisting of a strongly arched series of fused teeth, which are relatively more numerous (14–20 or more) than in the preceding genera, higher-crowned, and more laterally compressed. Teeth reflected forward so as to override one another toward their extremities, and fused for the greater portion of their length. Coronal apices acuminate, serrated, and more closely apposed to one another than in preceding genera. Series traversed by a median longitudinal canal along the base, but without lateral grooves. Lateral dentition and other parts of the skeleton unknown. Carboniferous. Type, *C. annectans* Eastman.

Helicoprion. — Symphysial series consisting of upwards of 150 fused teeth, very similar to the last in form, but coiled approximately into 3½ whorls. The teeth are much laterally compressed, bent forward so as to override one another toward the base, and traversed by a double lateral groove as well as by a median longitudinal channel along the base. Coronal apices acuminate, finely serrated along their anterior and posterior margins, and closely apposed to one another. Lateral dentition and other parts of the skeleton unknown. Permo-Carboniferous. Type and only known species, *H. bessonowi* Karpinsky.

The ancient family of Cestraciontidæ, to which these genera belong, shares with the Ceratodus-class of Dipnoans the distinction of having enjoyed a continuous range from the Devonian to the present day, certainly a most remarkable longevity. If we are right in regarding ***Protodus scoticus*** (Newton) as founded on the symphysial dentition of forms related to Campodus, this family makes its first appearance in the Lower Devonian of Canada and Great Britain. That it had attained considerable specialization at least as early as the Mesodevonian, is proved by the occurrence of formidable fin-spines, such as *Ctenacanthus wrighti*, in the Hamilton; and forms like *Helodus gibberulus* in the Chemung indicate that the divergence of the Cochliodont branch took place at a period considerably antedating the Carboniferous. As the group of Cladodont sharks, which is remarkable for its manifold varieties of piercing teeth, frequented the clear water of open seas and was undoubtedly of carnivorous habits, so, on the other hand, the groups armed with crushing teeth, such as are typified by Psammodont, Cochliodont, and Cestraciont sharks, early became adapted to bottom-living conditions, their fare probably consisting of hard-shelled prey such as mollusks, arthropods, and echinoderms. In all likelihood it is to the generalized Cestraciont type that we must look for the derivation of rays, which after all are not morphologically very different from sharks. A much depressed form of body is indicated by the arrangement of teeth in such forms as Psammodus, Copodus, and Archæobatis from the Carboniferous, and Janassa from the Permian.[1] The Devonian Tamiobatis is held to represent an intermediate type between sharks and rays; hence there is considerable reason to suppose that the modern ray-type was foreshadowed at even so remote a period as the Devonian.

Form and Orientation of Segments. — Interesting inquiries might be made respecting the mode of growth of the series in these four related genera, and into the processes of segmentation and fusion of the individual teeth; but we can only briefly touch upon these topics in the present paper. That various speculations have been entertained as to how the successional teeth were developed in Edestus, and that confusion still exists in the case of some species, regarding which are the oldest and which the newest formed segments, cannot be gainsaid. Dean's theory of a metameral origin for these bodies, and all others which fail to recognize their odontological nature, are of course to be dismissed in the light of our present information. Without a knowledge of the arrangement of the symphysial teeth in Campodus and Helicoprion, the orientation of incomplete series would still be conjectural in many cases, such as in the species of Campyloprion just described, and the types of *Edestus vorax*, *E. minor*, *E. giganteus*, etc. This difficulty has been

[1] On the form of body in Janassa and other Petalodonts, *cf. Jaekel, O.*, Ueber die Organisation der Petalodonten. Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, pp. 258–298, Pl. xiv., xv.

appreciated by most writers on Edestus, and is thus ably summarized by Karpinsky:[1]

"Als Endzähne, Scheitelzähne oder älteste Zähne (oder Segmente) fasst man bei den Edestiden mit Recht die von relative geringster Grösse auf. So ist es nicht schwer, bei den vorliegenden Resten von *Ed. lecontei* und *H. davisii* das Gipfelende und das Basalende zu unterscheiden. Allein an den erhaltenen Exemplaren zusammengewachsener Segmente von *Edestus minor*, *E. heinrichi*, und *E. giganteus* bleibt sich die Grösse der Zähne beinahe gleich und als das Scheitelende (das älteste) dieser 'Ichthyodorulithen' betrachtet man meist das rechte in Figure 3 [=type of *E. minor*] und das linke in Figure 5 [=type of *E. heinrichi*]. Mit andern Worten, man nimmt an, die Basis (Wurzel) eines jeden Zahnes richte sich von diesen nach der Seite der grössern Zähne (Segmente) hin. Die Vergleichung mit den Spiralsegmenten von *Helicoprion* dagegen führt uns zu dem entgegengesetzten Schlusse, dass die meisselförmige Basis der Zähne nach der Seite des Scheitelendes des Organs gekehrt sei."

The above interpretation of the three species of Edestus just enumerated is open to criticism on the ground that it assumes the segments are reflected in the reverse direction from that known to obtain in Campodus, Campyloprion, and Helicoprion, all of which have their teeth bent forward toward the base. About this there can be no question. A consideration of Dr. Newberry's views on the same subject of orientation and mode of growth in Edestus may not be out of place in this connection, and we quote from his latest published opinion as follows:[2]

"*Edestus davisii* is more like the intermandibular crest of Onychodus than are the other species of the genus. It is much more curved, and the arch of bone from which the denticles arise is laterally compressed or longitudinally grooved. Taken by itself, it renders the suggestion of Miss Hitchcock quite plausible. But it cannot be taken by itself; for wherever that species goes, *E. minor*, *E. heinrichi* and *E. giganteus* must follow; and while we can imagine a fish ten feet long with an arch of bone like *E. davisii* held between the extremities of the mandibles, it requires a much greater stretch of the imagination to conceive of a shark of such size that this relatively insignificant organ was twenty inches long and seven or eight inches wide [*i.e.*, deep]. Certainly such a monster would seem very much out of place in the lagoons of the coal marshes. Again, *E. heinrichi* is nearly straight, a foot long, rounded and massive at one end, thin and acute at the other; but the succession of denticles was *by additions to the acute end, which must have been behind*, for if it was situated in the symphysis, the blunt, rounded end would have formed the apex of the arch of the lower jaw; a condition of things scarcely comprehensible. If, now, we transfer this spine to the position of the post-

[1] *Loc. cit.*, p. 449.

[2] Monogr. U. S. Geol. Surv., Vol. XVI. (1889), p. 222.

dorsal fin, and bury it in the soft parts, all except the denticles, the elongation backward by the successive addition of sheaths and denticles becomes intelligible and natural."

Correct in his determination of the anterior and posterior extremities in *E. heinrichi* as such, Newberry yet deemed it "scarcely comprehensible" that any form of symphysial teeth should have their roots so enormously produced and enlarged in front; and accordingly he rejected this for the spine hypothesis of Leidy and Owen. The latter theory, however, involved certain difficulties of its own, which the same author thus comments upon:[1]

"It is also apparent that the growth of this organ was by additions to the summits of successive sheaths, each of which carried a denticle. This is strikingly different from the mode of growth of all sharks' spines known, as these increase by additions to the base, and are thus pushed upwards and lengthened. The same is true of all rostra which are used as weapons of defence or offence. If we consider the segments of Edestus as the homologues of a dental series we encounter the same difficulty. . . . We are therefore compelled to conclude that the spine was buried in the integuments throughout its entire length, the enamelled denticles alone projecting above the surface to form a saw, which would be a terrible weapon if placed upon some flexible portion of the body where it could be used with freedom and power. The extremity of the spine may have lain in a sheath, from which it could be partially erected by muscular action and used as the lancet of the surgeon fish (*Acanthurus*) is."

It is rather curious that so close an observer as Newberry, and following him Miss Hitchcock, should have entertained the idea that some of the segments of Edestus were freely movable upon one another, and possibly erectile. To notice Miss Hitchcock's theory[2] briefly, in passing, it must be said that in so far as she conceived Edestus to be homologous with the intermandibular arch of Onychodus, — a Crossopterygian ganoid, — her interpretation was at fault; but at the same time her reference of the series to the median line, in front of the lower jaw, was a close approximation to the truth, as has been finally revealed through a study of Campodus. And certainly without a knowledge of the latter, comparisons of Edestus with the symphysial series of Cestracion, Carcharias and other recent sharks, would have appeared fantastic in the extreme.

The way is now prepared for a more intimate comparison of the seg-

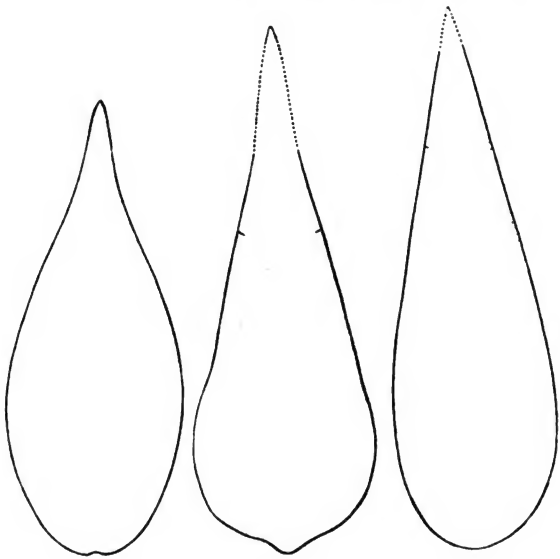
[1] *Loc. cit.* (1889), p. 223.

[2] Proc. Amer. Assoc. Adv. Sci., 1887 (1888), p. 260. Amer. Nat., Vol. XX. (1887), p. 847.

ments in these four closely related genera, more especially between Campodus and Edestus. Starting with Campodus as the least specialized member of the series, we find that the symphysial teeth are but little differentiated from those of the lateral series, except that they are greatly enlarged. They are only moderately compressed from side to side, the lateral extensions of their crowns are directed simply forward without appreciable curvature toward the base, and their fused roots are supported by the symphysial cartilage of the jaws without being anteriorly elongated. The coronal apices are very stout, rather obtuse, and with sharp, non-crenulated cutting edges, although faint wrinkles sometimes appear in the youngest-formed teeth. The longitudinal ridge extending over the coronal surface, so prominent in the lateral series, is obsolescent in the symphysial teeth. A continuous nutritive canal appears to have perforated the series in the median line immediately below the base of the apical portion, or in about the same relative position as shown by Karpinsky in Helicoprion (*cf.* this author's fig. 39). And, finally, the curvature of the series is not greater than in the corresponding arch of Cestracion or other existing sharks having the symphysial cartilage well developed (Lamnidæ, Carchariidæ), nor is there any difference in the number of segments.

In the evolution of Edestus and the more strongly coiled genera, the symphysial teeth have become considerably differentiated in form from the lateral series, their chief modifications consisting in a greater compression of the crown from side to side (*cf.* text-figure 6) with serration of the apical margins, a pronounced forward curvature toward the base, and in Edestus, an extreme elongation of the latter into a succession of gouge-like troughs or sheaths. With increasing compression of the segments, their basal portions become more closely crowded together, and more intimately fused at their extremities into a common mass of vasodentine, in consequence whereof spiral enrollment of the series follows almost as a matter of necessity, since the individual segments can no longer be shed with age. In Helicoprion the lateral compression, fusion, multiplication, and spiral enrollment of symphysial teeth is carried to an extreme degree, and the progressive stages which lead up to this condition are indicated by the three species of Campyloprion in the order named, — *C. lecontei*, *C. davisii*, and *C. annectans*.

Progressive modification takes place in two directions amongst these genera, starting with Campodus. In the three species of Campyloprion just enumerated, and one of Helicoprion, the tendency is toward enlargement of the apical at the expense of the basal portion of the teeth, with increase in the number of segments. A divergent series, however, is represented by the species of Edestus, in which the relatively few segments are not very intimately fused, while their coronal portions become reduced *pari passu* with the enormous development of the base. In fact, about all th~~e~~ remains of the crown in Edestus is the at



A. *B.* *C.*

Fig. 6.

Cross-sections of symphysial teeth of Edestus. *A*, Type of *E. heinrichi* N. & W. $\times \frac{1}{1}$. *B*, Type of *E. vorax* Leidy (after Leidy). $\times \frac{3}{4}$. *C*, Type of *E. giganteus* Newb., taken vertically through the penultimate tooth of the series. $\times \frac{1}{2}$.

apical portion, the two processes corresponding to the buttressed lateral faces of Campodus appearing as slender prolongations (*cf.* text-fig. 7). The relative compression amongst these various forms is apparent from their cross-sections, of which figures are given herewith. It will be noticed that in one species, *E. giganteus*, the cross-section is slightly asymmetrical. Whether this is due to accidental deformation, or is indicative of a paired series referable to the upper jaw, there are at present no means of determining. Campodus is the only genus in which the teeth exhibit marks of contact with opposing series.

Information regarding the mode of growth in Edestus is afforded by the detached segments of *E. heinrichi* and *E. minor*[1] which are known. Successional teeth are formed in the same way as in Campyloprion and Helicoprion, the only difference being that the bases of the newer formed segments ensheathe the older to a much greater extent. The first-formed or "terminal segment" of *E. heinrichi* is not a "solid bone," as stated by Newberry,[1] but possesses a gouge-like base the same as the

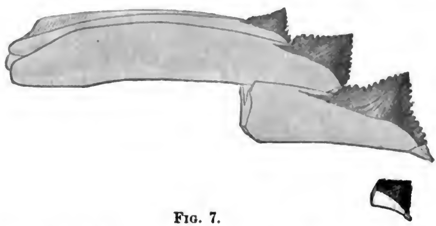


Fig. 7.

Edestus heinrichi N. & W. Coal Measures; Carlinville, Illinois. Series of segments belonging to a single individual. × ½.

rest. In the specimen figured by him as a supposed terminal segment, only the "denticle" [crown] is preserved, and the carbonaceous matrix which originally filled the interior of the sheath might readily be mistaken at first sight for "bone" or vasodentine. In text-figure 7 are shown several segments belonging to a single individual of *E. heinrichi*, in which the mode of succession is clearly discernible. The original, which forms part of the A. H. Worthen Collection in the Museum of Comparative Zoölogy, is from the Coal Measures ("roof of no. 5 coal") at Carlinville, Illinois. The segments fit snugly into one another in their natural position, but are shown slightly separated in the drawing. Associated with this specimen either naturally or accidentally was a fragmentary fin-spine of Ctenacanthus having a very coarse ornamenta-

[1] Ann. N. Y. Acad. Sci., Vol. IV., 1888, p. 120, Plate V., Figure 2*a* — Monogr. U. S. Geol. Surv., Vol. XVI. (1889), p. 223, Plate XXXIX., Figure 2*a*.

tion, and whose total length was probably about 15 cm. It is to be hoped that eventually a correlation may be established between Edestus and some of the huge dermal defences, such as Oracanthus, for instance, which accompany it in the Carboniferous.

II. ON SPINES OF CTENACANTHUS FROM THE MISSISSIPPIAN SERIES.

It is customary to recognize Ctenacanthus as a distinct genus, for although the spines are indistinguishable from those of Hybodus, they are not associated with Hybodus-like teeth in the Devonian and Carboniferous, none such having been found in rocks older than the Mesozoic. Newberry has brought forward some evidence to show that Orodus possessed spines of this nature, and this association is entirely consonant with the fact that Orodus and Campodus are Palæozoic forerunners of Hybodus. In view, however, of the almost universal occurrence of the spines of Ctenacanthus in a detached condition, it is proper to retain this as a provisional genus of Cestraciontidæ until such time as its relations have been definitely established.

Of primary importance in the distinction of species is the general conformation of the spine, especially its curvature, form of cross-section and length of inserted portion. Next in order are to be considered the number, shape, and direction of the longitudinal costæ, with the ornamentation of the same; and still further distinctive characters are to be found in the nature of the posterior face and anterior margin, or "cut-water." Sometimes weight has been placed on the above characters in reverse order from that indicated, and this has led to the establishment of doubtful species, or even genera of Ctenacanthus-like spines, such as *Anaclitacanthus semicostatus*, *Eunemacanthus costatus*, the types of *Acondylacanthus xiphias*, *Ctenacanthus limaformis*, etc.

Species of Ctenacanthus are especially numerous in the Kinderhook limestone of Iowa in the vicinity of Burlington, and elsewhere along the Mississippi River; and these may be divided into two general groups. The series formed by *C. varians*, *C. spectabilis*, *C. deflexus*, *C. solidus*, *C. clarki*, and *C. brevis* is characterized by abbreviate, stumpy proportions, by a similar pattern of ornamentation, and by having been inserted very obliquely in the integument. Spines of this nature are to be regarded as having pertained to the second (posterior) dorsal fin. They contrast strongly with the group of slender, elongated and tapering spines constituted by *C. formosus*, *C. sculptus*, *C. depressus*, *C. venustus*, *C. vetustus*, *C. denticulatus* and numerous others, which unquestionably belonged to the first dorsal fin.[1] Bearing this generalization in mind, we may pass on to a discussion of some new or little known species of this "genus," chiefly from the Kinderhook division of the Subcarboniferous. For the opportunity to describe the types belonging to the United States National Museum at Washington, the writer is greatly indebted to Mr. Frederic A. Lucas, Curator in charge of the Department of Comparative Anatomy.

SPECIES FOUNDED ON SPINES BELONGING TO THE ANTERIOR DORSAL FIN.

Ctenacanthus longinodosus, sp. nov.

Plate 5, Fig. 2.

As type of this species is selected a unique specimen belonging to the United States National Museum (Cat. No. 3393), and derived from the Kinderhook Limestone of the Mississippi Valley, probably from near Burlington, Iowa. It was formerly in the private collection of Mr. L. A. Cox, of Keokuk, Iowa. The spine is unfortunately not preserved in its entirety, the distal third or fourth and nearly all of the inserted portion having been broken away. It has also been subjected to some deformation, especially in the distal portion, prior to or during fossilization, and the walls of the pulp cavity have been forced inward by pressure.

Notwithstanding these imperfections, the spine is of much interest, and its unique style of ornamentation serves to distinguish it at once from all other species. About sixteen broad, flattened and highly polished costæ have their origin along the base of insertion, and are continuous throughout the length of the spine. They are parallel and non-bifurcating, and only a few small and incomplete adventitious ridges are intercalated between them, or engrafted upon their sides. The principal costæ are not all of uniform width or thickness, nor are they separated by regular intervals, some being narrower and more closely spaced than others. The intercostal spaces are plane and covered with fine longitudinal rugæ of precisely the same appearance as those of the inserted portion. The costæ are remarkable for their development at

[1] Science, n. s., Vol. XIV. (1901), p. 795.

fairly regular intervals of sculptured eminences or nodes (text-Fig. 8 *A*), a very unusual character in this genus, and in allusion to which the specific title is bestowed. As regards ornamentation, a certain resemblance will be observed to Oracanthus and the spines described by St. John and Worthen as *Glymmatacanthus rudis*, and *Batacanthus baculiformis*.

The longitudinal costæ of Ctenacanthus are commonly described as being "interrupted" by transverse ridges or swellings, implying that the latter are of subordinate importance, and that the truly essential structures are the longitudinal ridges. A study of the mode in which the ornamentation originates in the present specimen is sufficient to

A. *B*.

FIG. 8.

Ctenacanthus longinodosus sp. nov. Cross-section of spine. $\times \frac{1}{1}$. *A*, Portion of surface ornamentation of type-specimen. $\times \frac{1}{1}$. *B*, Same of a young individual, from near Burlington, Iowa. $\times \frac{1}{1}$.

convince one that this is not the correct interpretation. For, on directing our attention to the youngest part of the spine, that is to say, to the area along the line of insertion and along the border of the open pulp cavity, we find that growth of the costæ proceeds in the following manner: Small, irregular tubercles of vasodentine are deposited at intervals along the line of insertion, and although their summits are smooth at first, they soon become angulated and striated. As the spine protrudes more and more from the integument, these tubercles become widened somewhat, and at the same time their bases are elongated in a longitudinal direction. Should two of the newly formed tubercles become sufficiently approximated, either their summits or bases coalesce.

And sometimes, when a tubercle arises in an intercostal space and does not fuse with its neighbors on either side, its base may become elongated, other tubercles succeed behind it, and thus a new longitudinal ridge is formed. Owing to the increase in width of the spine toward the base, it rarely happens that after a ridge is once formed it is crowded out.

The slight concavity of the anterior margin, as seen in the type, might lead one to suppose that the spine was actually curved forward, but this appearance is in all probability due to distortion. The spine is preserved for a length of 16 cm., and has a maximum width of 4.5 cm. Its thickness at the base where the cross-section shown in text-figure No. 8 is taken, was probably about 1.8 cm., — making due allowance for the effects of crushing; and the pulp cavity remains open for a distance of 12.5 cm. The two parallel costæ extending along the anterior margin — it is not sharp enough to be called an edge — differ in no respect from the rest.

To this species is also referred a smaller and more fragmentary specimen belonging to the Wachsmuth Collection in the Museum of Comparative Zoölogy, obtained thirty years ago from the Kinderhook beds of Burlington, Iowa. That it is a young example, and not the distal end of a fully grown spine, is apparent from several reasons, such as the position of the pulp cavity as seen in cross-section, the straight course of the longitudinal costæ, and general delicacy of the specimen. As many as twelve parallel costæ occupy a space only 7 mm. wide. The nodes are separated by about the same intervals relative to the size of the costæ, as in the adult spine just described; their striation, however, is much obscured by weathering or wear. An enlarged view of its ornamentation is shown in text-figure 8 *B*.

Formation and Locality. — Kinderhook Limestone; Iowa.

Ctenacanthus lucasi, sp. nov.

Plate 6, Fig. 1.

The spine which is shown of slightly less than the natural size in Plate 6, Fig. 1, unfortunately lacks the greater part of the exserted portion, but so far as can be judged from the curvature, form of cross-section, and oblique line of insertion, it was of the same general form as *C. depressus* and *C. venustus* from the same horizon. Hence its position may be interpreted as having been in advance of the first dorsal fin. From other described species it is readily distinguished by its peculiar ornamentation.

The lateral face is ornamented with twenty regularly spaced longitudinal costæ, which continue perfectly straight without bifurcation, and are surmounted by conical or rounded tubercles separated by intervals equal to their own diameters. Some of the tubercles belonging to the anterior costæ show a tendency to become obliquely elongated, as in *C. solidus* and *C. decussatus*, and those of the posterior costæ are often delicately striated. None of the costæ exhibit a tendency toward posterior deflection, such as commonly occurs amongst other species; and the peculiar beaded appearance of the tubercles is quite remarkable for this genus. The passage of tubercles into transverse ridges, such as we have observed in the newly formed costæ of *C. longinodosus*, or in the latest formed portions of older costæ, is not evident in the present species, where the primitive tuberculated style of ornament seems to have been permanently retained. No costæ appear along the rounded anterior margin, which has been worn quite smooth prior to fossilization. The spine is preserved for a length of 12.5 cm., and the inserted portion has a maximum width of 3.4 cm. The cross-section shown in text-figure 9 is taken across the line of fracture where the rest of the spine has been broken away; the width here is 3 cm. and the thickness 1.4 cm.

FIG. 9.

Ctenacanthus lucasi, sp. nov. Cross-section of spine. × ½.

The specific title is bestowed in honor of Mr. Frederic A. Lucas, of Washington, to whom the writer is indebted for many courtesies, and for the loan of much valuable material. The original is preserved in the United States National Museum (Cat. No. 4844), and was collected by Mr. L. A. Cox from the Kinderhook Limestone, presumably in Iowa.

Formation and Locality. — Kinderhook Limestone; Iowa (?)

Ctenacanthus venustus, sp. nov.

Plate 3, Fig. 2.

Two examples are known of this species, the larger of which belongs to the Worthen Collection in the Museum of Comparative Zoölogy, and is selected as the type. The smaller spine, shown in Plate 3, Figure 2, belongs to the United States National Museum (Cat. No. 3385), and was formerly the property of Mr. L. A. Cox, of Keokuk, Iowa. Both specimens are from the Kinderhook group, and presumably from Iowa, although their exact locality is uncertain.

The general form and proportions of these spines agree with Newberry's description of the type of *C. depressus*,[1] which is likewise from the Kinderhook, and is now preserved in the Walker Museum of Chicago University. As the latter specimen is more or less abraded, it might be supposed that we have to do here with more perfect examples of the same species. It is certainly true that they all possess one character in common : and that is the extreme obliquity of the line of insertion, which extends for fully two-thirds the length of the spine. But unless both the description and drawing of Newberry are at fault, the differences immediately to be pointed out are sufficient to warrant the recognition of a distinct species.

According to Newberry, the lateral faces of *C. depressus* are "marked with about thirty longitudinal ridges," the tuberculation of which is "inconspicuous;" and it is further stated that "along the anterior border the ridges are set with closely approximated, simple and plain tubercles; on the sides the longitudinal ridges are nearly or quite smooth." But the two specimens here placed in a distinct species have much finer and more numerous longitudinal costæ than are represented as occurring in *C. depressus*, and these can by no means be described as "inconspicuously tuberculose." On the contrary, they are very prominently decussated, the transverse ridges being sharp and fine, and so closely crowded that as many as from seventeen to twenty are to be counted within the length of one centimeter. These decussations, when completely formed, extend entirely across the costæ in a transverse or oblique direction, but their growth is frequently arrested, so that they appear as denticulations spaced at intervals of their own length along either side of the costæ. The ten filiform costæ lying next to the posterior margin are so closely apposed as to be almost contiguous, and these are surmounted by small conical tubercles, none of which are striated, however. Nor are any of the other transverse ridges striated.

The remarkably oblique line of insertion is fully 10 cm. long in the type, and the pulp cavity remains open for the whole of this distance, or for more than half of the total length of the spine. The section shown in text-figure no. 10 *A* is taken at the point where the line of insertion meets the posterior margin. The latter is beset from this point onward to the apex with very small and closely spaced conical protuber-

[1] *Newberry, J. S.*, Trans. New York Acad. Sci., Vol. XVI. (1897), p. 291.

ances, which are larger than the adjacent tubercles, but not sufficiently developed to be styled denticles. A prominent median ridge extends along the posterior face from the opening of the pulp cavity to the apex. The cross-section shown in text-figure 10 is taken at a distance of 8 cm. from the tip of the inserted portion, that in 10 *A* at a distance of 15 cm., and that in No. 10*B* at a distance of 22 cm.

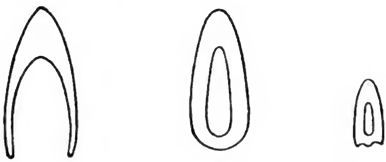


FIG. 10.

Ctenacanthus venustus, sp. nov. Cross-sections near the base, middle (*A*), and distal portion (*B*), of the type-specimen. × ½.

About 55 longitudinal costæ are to be counted along the line of insertion in the larger specimen, which has a total length of 34 cm. and about 40 in the original of Plate 3, Figure 2, which is preserved for a length of a little over 14 cm. The type of *C. depressus* Newberry, which is intermediate between these two examples in size, has only 30 continuous longitudinal costæ, and is apparently less laterally compressed. As representatives of the group of slender, elongated spines, which are supposed to be correlated with the anterior dorsal fin, the species known as *C. depressus*, *C. venustus*, and *C. lucasi* stand in the same mutual relationships as do the stumpy and abbreviated spines from the same horizon, such as *C. spectabilis*, *C. varians*, *C. deflexus*, *C. solidus*, etc., those of either group being distinguished from one another chiefly by ornamental details.

Formation and Locality. — Kinderhook Limestone; Iowa (?).

Ctenacanthus, sp. indet.

A very large spine, evidently of this genus, was obtained by Mr. L. A. Cox from the Keokuk limestone in the vicinity of Keokuk, Iowa, and is now preserved in the United States National Museum (Cat. No. 3480). It is much abraded, and only the exserted portion remains.

This has much the same form as *C. acutus* from the same horizon, being very straight and gradually tapering, only it is about thrice the size of the latter. It exhibits a length of 28 cm., a maximum width of 3.5 cm. on the lateral faces, and a thickness of over 3 cm. It is too imperfect, however, for closer identification. The type of *C. acutus* is preserved in the United States National Museum.

Formation and Locality. — Keokuk Limestone; Keokuk, Iowa.

Ctenacanthus decussatus, sp. nov.

Plate 6, Fig. 2.

The specimen shown of the natural size in Plate 6, Figure 2, bears the United States National Museum catalogue number 4846, and was obtained from the Kinderhook limestone at an uncertain locality, but presumably from either Iowa or Illinois. It is preserved for a length of 12 cm., shows the whole of the inserted portion, and sufficient of the

A.

FIG. 11.

Ctenacanthus decussatus, sp. nov. Cross-sections of spine near point of insertion and middle portion (*A*). × ½.

exserted to afford a fair idea of its form and surface ornamentation. The spine is remarkably robust, being almost as thick as it is wide; and in this respect it contrasts strongly with other species from the same horizon, the majority of which are much laterally compressed.

In cross-section (*cf.* text-figure 11) the spine resembles *C. buttersi* from the Lower Coal Measures, and *C. pellensis* from the St. Louis limestone, but the ornamentation is different from both. The general outline was probably of the same elongated nature as *C. denticulatus*, *C. depressus*, and *C. venustus*, the last two being likewise from the Kinderhook group. The sides are ornamented with prominent decussated longitudinal costæ, about 24 of which are to be counted along the line of insertion, and but 17 along the line of fracture where the section shown in text-figure No. 11 *A* is taken. The costæ increase in number by bifurcation, and diminish gradually in width on approaching the posterior margin. *Pari passu* with the diminution in width of the costæ, the transverse ridges which cross them become less and less elongated, until in the latest formed costæ they are almost tubercular. None of the transverse crests are striated, and they are spaced at approximately regular intervals apart. Occasionally the decussations belonging to several consecutive costæ extend across the intercostal spaces and become fused.

The anterior margin is rounded and bears a somewhat wider longitudinal ridge than the rest, from which only one or two bifurcations are given off. The posterior walls of the pulp cavity appear to be slightly swollen, and the cavity itself is slightly open throughout the entire length of the part preserved. No other examples of this species have as yet fallen under the writer's observation.

Formation and Locality. — Kinderhook Group; Iowa or Illinois.

Ctenacanthus gracillimus N. and W.

1866. *Ctenacanthus gracillimus* Newberry and Worthen, Pal. Ill., Vol. II., p. 126. Plate XIII., Figure 3.

1866. *Leptacanthus* (?) *occidentalis* Newberry and Worthen, *ibid.*, p. 116, Plate XII., Figure 2.

1875. *Acondylacanthus occidentalis* St. John and Worthen, *op. cit.* Vol. VI., p. 433.

1883. *Ctenacanthus gracillimus* St. John and Worthen, *op. cit.*, Vol. VII., p. 238, Plate XXIV., Figure 1.

1889. *Acondylacanthus occidentalis* J. S. Newberry, Monogr. U. S. Geol. Surv., Vol. XVI., p. 206, Plate XXV., Figure 6.

Although this is one of the most abundant ichthyodorulites occurring in the St. Louis limestone, and a number of more or less perfect examples have been obtained, confusion exists regarding both its generic and specific titles. There can be no doubt as to the correctness of Messrs. St. John and Worthen's conclusion that the spines described as "*Leptacanthus* (?) *occidentalis*" by Newberry and Worthen in Vol. II. of the Palæontology of Illinois are only worn or imperfect examples of the same species as *Ctenacanthus gracillimus* N. and W., likewise published in Volume II. (1866). These authors had then to decide which of Newberry and Worthen's figured specimens should be selected as the type, and by which of the two names the species should be designated. It is a well-established principle of nomenclature that in cases like this, or as between names the equal pertinency of which may be in question, "preference shall be given to that which is open to least doubt" (*A. O. U. Code*, Canon XVII.).

As a matter of fact, when these two "species" were united by St. John and Worthen in 1883, some slight doubt was expressed as to their identity, and the authors very properly chose for their common designation that which was founded on the most perfect specimen, and hence was open to least doubt, namely, *C. gracillimus*. By this decision the spine figured in Plate XIII. Figure 3 of the Illinois Palæontology, Vol. II., was definitely established as the type-specimen, and the only question is whether it actually belongs to Ctenacanthus, or should be removed to Acondylacanthus as was proposed by Newberry in 1889. The latter author rests his claim upon a worn, immature, and distorted specimen, now in the Museum of Columbia University, and very much inferior in point of preservation to the spine figured by St. John and Worthen in Vol. II. of the Illinois Palæontology, to which no reference is made by Newberry.

FIG. 12.

Ctenacanthus gracillimus N. & W. St. Louis Limestone; Missouri. Portion of ornamentation. × ½.

The correctness of St. John and Worthen's determination is confirmed by several additional specimens which have come under the writer's observation, all of which show tuberculated costæ, and the absence of this character in Newberry's spine is probably due to abrasion. One example in particular, from the St. Louis limestone, and belonging to the Museum of Comparative Zoölogy, exhibits the finer ornamentation very distinctly in its proximal portion (*cf.* text-figure 12) where the tubercles are seen to be small, stellated, and rather widely spaced in proportion to the extreme fineness of the costæ.

Just as *C. xiphias* (St. J. and W.), from the Keokuk limestone was first assigned to Acondylacanthus on the evidence of a worn specimen, so the true relations of *C. gracillimus* were rendered obscure by faulty preservation. In the same connection it may be remarked that another very interesting group of spines from the St. Louis limestone has been for the same reason misinterpreted by various authors. These are referable to the same species as occurs in the Carboniferous Limestone of Armagh and Gloucestershire, and described as *Physonemus arcuatus* by M'Coy.[1] Examples denuded of their

[1] Ann. Mag. Nat. Hist. (2), Vol. II (1848), p. 117.

surface ornamentation have been figured by St. John and Worthen[1] as *Drepanacanthus reversus*, and by Newberry[2] as *Physonemus stellatus*.

The theoretical association of Physonemus, including Xystracanthus, Drepanacanthus, and Batacanthus, with the teeth of various species of Petalodonts, as proposed by Jaekel (*loc. cit.*, p. 285), may be considered as negatived by the discordant distribution in the Mississippian series of these two classes of remains.

Formation and Locality. — St. Louis limestone; Missouri, Illinois, Indiana, and Michigan.

SPECIES FOUNDED ON SPINES BELONGING TO THE POSTERIOR DORSAL FIN.

Ctenacanthus coxianus St. John and Worthen.

1883. *Ctenacanthus coxianus* St. John and Worthen, Pal. Illinois, Vol. VII., p. 233, Pl. XXI., Fig. 1.

This species was founded on a unique but fragmentary and abraded spine from the Keokuk limestone of Iowa, and no further examples have been recorded from this or from other horizons. An imperfect spine, denuded of most of its ornamentation, but apparently referable to this species, is preserved in the Worthen Collection in the Museum of Comparative Zoölogy, and was derived from the Kinderhook limestone of Iowa. Considerable resemblance is to be observed between this species and *C. furcicarinatus* from the Waverly sandstone of Kentucky.

Formation and Locality. — Kinderhook and Keokuk Groups; Iowa.

Ctenacanthus spectabilis St. John and Worthen.

Plate 5, Fig. 1.

1875. *Ctenacanthus spectabilis* St. John and Worthen, Pal. Illinois, Vol. VI., p. 420, Pl. XV., Figs. 1*a*–1*e*.

This species was founded on a unique spine from the Kinderhook limestone of Legrande, Iowa, the more salient characters of which were stated to consist in its "great breadth along the oblique line of insertion and the abrupt posterior deflection in the curvature of the costæ,

[1] Pal. Ill., Vol. VI. (1875), p. 456, Plate XIX., Figure 5 (*non* Figure 6). — *Ibid.*, Vol. VII. (1883), p. 253, Plate XXIV., Figure 5.

[2] Monogr. U. S. Geol. Surv., Vol. XVI. (1889), p. 200, Plate XXI., Figure 12.

producing a frayed appearance in that portion of the posterior margin." From *C. varians* and *C. brevis* it is distinguished by certain details of its ornamentation. In particular, its anterior margin is described as bearing a "prominent, eccentric marginal ridge, from which frequent bifurcations are sent off on either side, each offshoot being more attenuated and curved posteriorly on approaching the posterior margin, forming throughout closely approximated, rounded ridges, of which there are about fifty, counting along the inferior margin, and less than half that number two-thirds the distance to the apex."

There can be no hesitation in referring to this species the original of Plate 5, Fig. 1, which is from the same horizon, and belongs to the United States National Museum (Cat. No. 4845). This spine displays the general outline and ornamentation very satisfactorily, notwithstanding it has been much laterally compressed by mechanical agencies. It has a total length of 15 cm., and maximum breadth of 3 cm. A sharp and prominent marginal ridge extends for the entire length of the anterior border, and forty or more longitudinal costæ terminate along the very oblique line of insertion. The only noteworthy particular in which it differs from the type relates to the ornamentation, which is of the decussated instead of the tuberculose pattern. Isolated and well-marked tubercles predominate in the type, although it is stated that along the anterior margin "they present the appearance of closely approximated decussations, apparently the result of abrasion, the entire crest of the ridges [costæ] being reduced to a smooth polished surface." But in the example before us distinct tubercles are almost entirely wanting, and the costæ are crossed by exceedingly numerous transverse ridges, the crests of which were apparently sharp and smooth.

That this difference in ornamental details is of minor importance is proved by the conditions existing in *C. varians*, where tubercles of diverse shape are variously disposed in different parts of the spine. They frequently surmount the costæ in double or even triple rows, and the "pairs of nearly circular tubercles often coalesce, forming a single transverse tubercle, which latter is the prevailing, if not persistent form in the posterior costæ."[1] A similar fusion of adjacent tubercles to form a single transverse ridge has already been noticed in *C. longinodosus* (*v. supra*, p. 80), hence it is not surprising that this process should be observed in a varying degree amongst different species, being sometimes limited to particular spines of the same species, and sometimes to different portions of a single spine.

Formation and Locality. — Kinderhook Group; Iowa and Illinois.

[1] *Loc. cit.* (1875), p. 422.

Ctenacanthus varians St. John and Worthen.

1875. *Ctenacanthus varians* St. John and Worthen, Pal. Illinois, Vol. VI., p. 422, Pl. ~~XVI.~~, Fig. 2. XIV

1875. *Ctenacanthus speciosus* St. John and Worthen, *ibid.*, p. 424, Pl. XIV., Figs. 3, 4.

Type. Fractured spine; Museum of Comparative Zoölogy.

Regarding the type-specimen of *C. varians*, now preserved in the Cambridge Museum, Messrs. St. John and Worthen speak as follows (Pal. Illinois, Vol. VI., p. 423): "The solitary example which we have examined of the present form represents a spine probably seven inches in length, and though broken and parts are missing, sufficient remains, together with the perfect condition of the external characters, to show its distinctive features as contrasted with other forms. . . . Compared with *C. speciosus*, with which it has in common the same general outline and similar style of ornamentation, its distinguishing peculiarities consist in its more robust proportions and greater lateral thickness, the double row of tubercles along the anterior ridges, and the more prominent denticles arming the postero-lateral angles."

The same authors, in describing *C. speciosus*, again call attention to the close resemblance between the latter form, of which they possessed several fragments besides the type, and the unique specimen of *C. varians*. From comparisons of a large series of Selachian fin-spines, the present writer has been led to the conclusion that the supposed differences between *C. varians* and *C. speciosus* are of too trifling nature to be considered of specific importance; hence the latter title had best be abandoned.

Formation and Locality. — Kinderhook Group; Flint River, near Burlington, Iowa.

Ctenacanthus semicostatus St. John and Worthen.

1875. *Anaclitacanthus semicostatus* St. John and Worthen, Pal. Illinois, Vol. VI. p. 443, Pl. XVI., Fig. 14.

Type. Abraded and distorted spine; Museum of Comparative Zoölogy.

This species is founded on a much abraded and distorted spine which is now preserved in the Museum of Comparative Zoölogy at Cambridge, and whose relations are evidently with the genus Ctenacanthus instead of Anaclitacanthus. Traces remain in some places of the original tuberculation of the costæ, and it is evident that the latter increased by bifurcation, and were much deflected along the posterior margin. These conditions are characteristic of the group represented by *C. varians* and *C. spectabilis* from the Kinderhook, which was most prolific at the beginning of the Lower Carboniferous, and entered almost immediately thereafter upon its decadence.

Formation and Locality. — Upper Burlington Group; Burlington, Iowa.

Ctenacanthus solidus, sp. nov.

Plate 7, Figure 3.

Type. Spine referred to the posterior dorsal fin: United States National Museum.

Three spines from the Kinderhook of Iowa have come under the writer's observation, which belong to the group represented by *C. varians, C. spectabilis, C. deflexus*, etc., and yet differ from all these in certain details by which they may be specifically distinguished. Two of these specimens belong to the United States National Museum, the more perfect of which bears the catalogue number 3383, and is selected as typical. The smaller spine is shown nearly of the natural size in Plate 7, Figure 3, and is catalogued as number 4843. The third specimen referred to forms part of the A. H. Worthen Collection in the Museum of Comparative Zoölogy at Cambridge.

The spines referred to this species are very similar in proportion and general outline to those of *C. spectabilis*, but their ornamentation is coarser, and there are fewer longitudinal costæ. These do not exhibit the abrupt posterior deflection on approaching the line of insertion, which is so conspicuous a feature of *C. spectabilis* and *C. varians*, and the line itself is shorter and less oblique than in those forms. The costæ, in addition, are occupied in the present species by prominent, well-separated tubercles, which may be either rounded or obliquely elongated, and whose summits are distinctly wrinkled or striated. Another distinguishing character is furnished by the anterior margin. In *C. spectabilis* this is more or less angular, and bears a prominent sharp ridge, from which "frequent bifurcations are sent off on either side, and these again bifurcate descending, each offshoot being more attenuated and curved posteriorly on approaching the posterior margin," forming in all about fifty rounded ridges to be counted along the line of insertion. The present species has a more rounded anterior margin (*cf.* text-figure 13) than *C. spectabilis*, and the sharp marginal ridge of that species is here replaced by a row of tubercles somewhat coarser or more elongated than the rest. This latter condition approximates that observed in *C. coxianus* from the Keokuk limestone.

In *C. mayi* about a dozen longitudinal costæ are to be counted along the line of insertion; in *C. coxianus* as many as 18 or 20; in *C. solidus* upwards of 30; in *C. spectabilis* about 50; and in *C. varians* 80 or more. Amongst these only *C. varians* agrees with the species under discussion in having sculptured or striated tubercles, and this character is also common to *C. brevis* from the Lower Carboniferous of Ireland, and to *C. longinodosus*, as described above. It is thus apparent that the number and direction of the costæ are of prime importance in the distinction of species.

FIG. 13. *Ctenacanthus solidus*, sp. nov. Cross-section of type-specimen in its basal portion. × ½.

The spine shown in Plate 7, Figure 3, is preserved for a length of 9.5 cm. and has a maximum width of 3.5 cm. The type-specimen belonging to the United States National Museum has the costæ more perfectly preserved than either of the co-types. Its cross-section, shown in the accompanying text-figure 13, is well displayed by the fracture across the base, but the thickness at this point is exceeded by both of the co-types. None of these spines retain traces of posterior denticles, although it is very probable that such were formerly present.

Formation and Locality. — Kinderhook; Iowa and Illinois.

LIST OF SPECIES OF CTENACANTHUS OCCURRING IN THE MISSISSIPPIAN SERIES.

NAME OF SPECIES.	Kinderhook.	Burlington.	Keokuk.	St. Louis.	Chester.
1. *C. coxianus* St. J. and W.	x	—	x	—	—
2. *C. decussatus* Eastm.	x	—	—	—	—
3. *C. depressus* Newb.	x	—	—	—	—
4. *C. longinodosus* Eastm.	x	—	—	—	—
5. *C. lucasi* Eastm.	x	—	—	—	—

LIST OF SPECIES OF CTENACANTHUS OCCURRING IN THE MISSISSIPPIAN SERIES (*continued*).

Name of Species.	Kinderhook.	Burlington.	Keokuk.	St. Louis.	Chester.
6. *C. sculptus* St. J. and W. . . .	x	—	—	—	—
7. *C. semicostatus* (St. J. and W.) .	x	—	—	—	—
8. *C. solidus* Eastm.	x	—	—	—	—
9. *C. spectabilis* St. J. and W. . . .	x	—	—	—	—
10. *C. varians* St. J. and W. . . .	x	—	—	—	—
11. *C. venustus* Eastm.	x	—	—	—	—
12. *C.* (?) *burlingtonensis* St. J. and W.	—	x	—	—	—
13. *C. gradocostatus* St. J. and W. . .	—	x	—	—	—
14. *C. acutus* Eastm.	—	—	x	—	—
15. *C. cylindricus* Newb.	—	—	x	—	—
16. *C. excavatus* St. J. and W. . . .	—	—	x	—	—
17. *C. keokuk* St. J. and W.	—	—	x	—	—
18. *C. xiphias* (St. J. and W.) . . .	—	—	x	—	—
19. *C. costatus* N. and W.	—	—	—	x	—
20. *C. deflexus* St. J. and W. . . .	—	—	—	x	—
21. *C. gemmatus* St. J. and W. . . .	—	—	—	x	—
22. *C. gurleyi* Newb.	—	—	—	x	—
23. *C. harrisoni* St. J. and W. . . .	—	—	—	x	—
24. *C. littoni* Newb.	—	—	—	x	—
25. *C. pellensis* St. J. & W.	—	—	—	x	—
26. *C. angulatus* N. and W.	—	—	—	—	x
27. *C. canaliratus* St. J. and W. . .	—	—	—	—	x
28. *C. similis* St. J. and W.	—	—	—	—	x

III. ON ACANTHODIAN REMAINS FROM THE COAL MEASURES OF MAZON CREEK, ILLINOIS.

Representatives of the Acanthodii are extremely rare in the Palæozoic rocks of North America, and the only species hitherto described are restricted to the Devonian of the United States and Canada. If we neglect the detached spines of Machæracanthus, and the indeterminable mass of scales described by Dr. J. M. Clarke[1] as *Acanthodes* (?) *pristis*, American Acanthodians are limited to but one species each of

[1] Bull. U. S. Geol. Survey, No. 16 (1885), p. 42.

Acanthodes and Mesacanthus, namely *A. concinnus* Whiteaves and *M. affinis* (Whiteaves) from the Upper Devonian of Scaumenac Bay, Canada.

The occurrence of a new and very large species of Acanthodes in the Coal Measures of Mazon Creek has been previously reported by the writer,[1] but descriptions of the same have been reserved until now. The material upon which the following diagnoses are based belongs to the S. S. Strong collection in the Peabody Museum of Yale College. Nearly all of the vertebrate remains in this handsome collection, comprising several hundred specimens of the usual concretionary type, were very generously placed in the writer's hands for investigation by the late Professor O. C. Marsh, and quite recently a number of additional nodules have been loaned for the same purpose by Dr. C. E. Beecher. It is hoped that the structure of certain Coelacanths, Platysomids, and Palæoniscids, of which several complete examples exist in the same collection, may be elucidated in a future publication.

Acanthodes marshi, sp. nov.

Plate 6, Fig. 3; Plate 7, Figs. 1, 2.

To this species are referred a number of large fin-spines, one of them having the dermal rays attached, and also a mass of shagreen granules of correspondingly large size. All these specimens are preserved in ironstone nodules from the well-known Mazon Creek locality in Grundy County, Illinois. The scale-bearing nodule, upon which the species is founded, is shown in Plate 7, Figure 1. The shagreen granules occupy a space of several square centimeters, and present the following characters:

Scales in the form of quadrate granules averaging about one square millimeter in size, smooth and polished externally, gently convex or rounded on both the outer and attached surfaces. Internal structure consisting of fine layers of dentine arranged in quadrate fashion about a small central pulp-cavity. Attached surface of some scales crossed by a shallow diagonal groove.

Not only are the scales much coarser than those of *A. bronni* and *A. wardi*, which attain as large a size as any, but the fin-spines are considerably longer and stouter, averaging about 9 cm. long, and from 5 to 8 mm. wide. The spines are gently curved backward throughout their length, have tapering distal extremities, and are faintly grooved

[1] Science, n. s., Vol. IX. (1899), p. 642; *ibid.*, Vol. XI. (1901), p. 795.

along the anterior and sometimes also the posterior margin. In fractured specimens the central longitudinal cavity is seen to be infiltrated with a white silicious substance.

In Plate 6, Figure 3, is shown a very interesting pectoral fin preserved in counterpart (Yale Museum Cat. No. 295), and retaining the actinotrichia in natural association with the spine. The latter is preserved for a length of 8 cm., has a width of 8 mm., and thickness of 4 mm. The fibrous rays are quite long and numerous as compared with other species, and extend well up towards the proximal end of the spine. There is no trace here of a basal cartilage abutting against the side of the spine, owing to deficient preservation in this region, hence the present specimen is unable to throw any light on the partly conjectural restorations of Reis,[1] Fritsch,[2] Jaekel,[3] and others. In view of the extreme interest attaching to the endoskeletal structure of the paired fins, it is tantalizing to find just those parts missing which are most needed to clear up certain problematical details. Neither does this specimen display any of the dermal granules with which the fin-membrane was stiffened, but these are well exhibited in a smaller fin, possibly identifiable as the dorsal fin of a young individual, shown in Plate 5, Figure 3. In this specimen the limit of the exoskeletal part, or which is the same thing, the outline of the body-wall, is very distinctly shown. Although the spine is only 2.5 cm. long, it is about as wide in proportion as the adult spines. The smaller fin is preserved in counterpart like the majority of fossil remains found in concretions.

The specific title is dedicated to the honored and enduring memory of the late Professor Othniel Charles Marsh.

Formation and Locality. — Coal Measures; Mazon Creek, Illinois.

Acanthodes beecheri, sp. nov.

Text-figure 14.

A very small species, attaining an extreme length of about 5.5 cm. Body elongated and slender, the maximum depth being contained about nine times

[1] *Reis, O. M.*, Ueber Acanthodes bronni, Agassiz. Morphol. Arb., Vol. VI. (1896). Plate VI., Fig. 11.

[2] *Fritsch, A.*, Fauna der Gaskohle, Vol. III. (1893), p. 71.

[3] *Jaekel, O.*, Ueber die primäre Zusammensetzung des Kieferbogens und Schultergürtels. Verhandl. deutsch zool. Ges. (1899), p. 256, text-fig. 2. — On the microscopic structure of Acanthodian scales, see the articles by Reis already cited, and Rohon's Memoir on Die Obersilurischen Fische von Oesel (Mém. Acad. Imp. Sci. St. Petersburg, Vol. XLI., 1893, No. 5, p. 22).

in the total length. Pectoral spines not much stouter or longer than the others; pelvic fins small, slightly nearer the pectorals than the anal; anal fin slightly larger than the dorsal, which is placed immediately behind. Length of dorsal and anal spines greater than maximum depth of the trunk. Caudal lobe remarkably elongate. Scales very minute.

This species is represented by two nearly complete individuals preserved in counterpart, one of which has a total length of about 5.5 cm. (Yale Museum Cat. No. 630), and the other about 5 cm. (Cat. No. 114). Neither of these exhibits the caudal region in its entirety, however, and the heads are not satisfactorily preserved. Only the dorsal and anal fin-spines, with their dermal rays, are displayed by the larger specimen; but in the smaller individual all the fin-spines are preserved, although the dorsal is slightly displaced and the distal ends of the pectorals are wanting. The accompanying text-figure 14 is of composite nature, being based upon both specimens; it represents the general outline and proportions of the fins, the restored parts being shown in dotted lines.

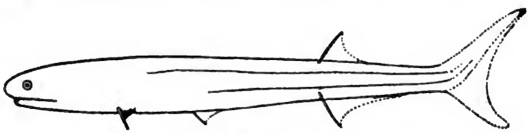


FIG. 14.

Acanthodes beecheri, sp. nov. Coal Measures; Mazon Creek, Ill. Restored outline. × ½.

In size and general configuration this species resembles the Devonian Mesacanthi, especially *Mesacanthus mitchelli* (Egerton) from the Scottish Old Red Sandstone, and *M. affinis* (Whiteaves) from the Upper Devonian of Scaumenac Bay, Canada, but differs from them as well as from other species of Acanthodes in the position and relative proportions of the fins. The most marked characteristic of the present form consists in the small size of the pectorals as compared with the pelvic, dorsal, and anal fins. In this respect it furnishes an exception to the generalization that in the course of geological time the pectoral fins of Acanthodians become enlarged at the expense of the pelvic, while the two pairs become approximated. In the Lower Permian *A. bronni* the pelvic fins are greatly reduced, and in the so-called Traquairia, from the same formation, they are entirely wanting. We have in the species under discussion a survival of the primitive conditions observed in Mesacanthus, with the exception that the free spines between the paired fins have become lost. Whereas in most Acanthodians the dorsal exceeds the anal more or less in size, in this case it is the anal that is slightly the larger.

The squamation is very fine indeed, and on this account the individual granules can scarcely be recognized. The lateral line, however, is very distinctly shown in both examples. In the larger specimen the calcified meckelian cartilage is preserved on one side, and is substantially of the same form as shown by Jaekel[1] and Reis[2] in *A. bronni*. The smaller specimen exhibits a displaced "extramandibular spine" with long fine rays, such as occurs in *A. bronni* and *A. (Traquairia) pygmæa*. Teeth are absent. By an odd chance a small Pleuracanthus tooth has happened to lodge directly over the posterior part of the cranium in the larger specimen, thus increasing the obscurity of this region. The compact structure of the fin-spines and mandibular calcifications leaves no room for doubt that these are adult individuals, notwithstanding their small size.

The species is named in honor of Professor Charles E. Beecher as a slight tribute of personal esteem, and in grateful appreciation of his many friendly courtesies.

Formation and Locality. Coal Measures; Mazon Creek, Illinois.

[1] *Jaekel, O.*, Ueber die primäre Zusammensetzung des Kieferbogens und Schultergürtels. Verhandl. deutsch. zool. Ges. (1899), p. 252, text-fig. 1. — Zeitschr. deutsch. geol. Ges., Verhandl., Vol. LI., 1899, p. 56, text-fig. 1.

[2] *Reis, O. M., loc. cit.*, Plate VI., Figs. 1, 3, 4.

LIST OF CARBONIFEROUS VERTEBRATES OCCURRING AT MAZON CREEK, ILLINOIS.

AMPHIBIA.

1. *Amphibamus grandiceps* Cope.

ELASMOBRANCHII.

2.	*Pleuracanthus* (*Diplodus*) *compressus* Newb.	(Occurs also at Linton, Ohio, and in Indiana.)
3.	" " *latus* Newb.	(Occurs also in Ohio and Indiana.)
4.	" " *lucasi* Hay	
5.	*Acanthodes beecheri*, sp. nov.	
6.	" *marshi*, sp. nov.	
7.	*Campodus scitulus*	(St. J. and W.) *fide* O. H. St. John.

DIPNOI.

8.	*Ctenodus* sp. indes.	
9.	*Sagenodus foliatus* Cope.[1]	
10.	" *lacovianus* Cope.[1]	
11.	" *occidentalis* (Newb. and W.)[1]	(Occurs also at Linton, Ohio.)
12.	" *quadratus* (Newb.)[1]	(Occurs also at Linton, Ohio.)
13.	" *quincunciatus* Cope.[1]	
14.	" *reticulatus* (Newb. and W.)[1]	
15.	" *textilis* Hay.[1]	

CROSSOPTERYGII.

16.	*Rhizodopsis* (?) *mazonius* Hay.[1]	
17.	*Coelacanthus exiguus*, Eastm.	
18.	" *robustus* Newb.[1]	(Occurs also at Linton, Ohio.)

ACTINOPTERYGII.

19.	*Eurylepis*, sp. indet., *fide* J. S. Newberry.	
20.	*Rhadinichthys gracilis* (Newb. and W.).	
21.	*Elonichthys hypsilepis* Hay.	
22.	" *peltigerus* Newb.[2]	(Occurs also at Linton, Ohio).
23.	" *perpennatus* Eastm.	
24.	*Platysomus circularis* Newb. and W.	
25.	" *lacovianus* Cope.	
26.	" *orbicularis* Newb. and W.	

[1] Founded on scales.

[2] Including also the so-called "*Amblypterus macropterus*" Newb. and W.

EXPLANATION OF PLATES.

PLATE 1.

Campodus variabilis (Newb. and W.) Coal Measures; Cedar Creek, Nebraska. Symphysial dentition, belonging presumably to the lower jaw, and displaying eleven fused teeth, viewed from the right-hand side. Reproduced from a photograph by Mr. A. Hyatt Verrill without retouching. Original preserved in the Museum of the State University of Nebraska. $\times \frac{4}{5}$.

PLATE 2.

Campodus variabilis (Newb. and W.). Coal Measures; Osage County, Kansas. Symphysial dentition belonging presumably to the lower jaw, with naturally associated antero-lateral series, viewed from the right-hand side. Coronal apices of all except the posterior tooth have been broken away. Reproduced from a photograph by Mr. C. H. Currier without retouching. Original preserved in the Museum of Comparative Zoölogy at Cambridge, Mass. (Cat. No. 749). $\times \frac{4}{5}$.

PLATE 3.

Fig. 1. *Campodus variabilis* (Newb. and W.). Coal Measures; Osage County, Kansas. Oral aspect of same specimen shown in Plate **2**, with the anterior extremity shown uppermost. $\times \frac{5}{8}$.

Fig. 2. *Ctenacanthus venustus*, sp. nov. Kinderhook limestone; Iowa (?). Lateral aspect of spine referred to the anterior dorsal fin, and belonging to an immature individual. Original preserved in the United States National Museum at Washington. (Cat. No. 3385). $\times \frac{1}{1}$.

PLATE 4.

Campyloprion annectans Eastm. Carboniferous or Permo-Carboniferous; locality unknown. Symphysial dentition, showing portions of about 20 fused teeth, viewed from the left-hand side. Reproduced from a photograph by Mr. C. H. Currier without retouching. Original preserved in the Museum of Comparative Zoölogy at Cambridge, Mass. $\times \frac{2}{3}$.

PLATE 5.

Fig. 1. *Ctenacanthus spectabilis* St. J. and W. Kinderhook Limestone; Mississippi Valley. Left lateral aspect of spine referred to the second dorsal fin. Original preserved in the U. S. National Museum. (Cat. No. 4845). $\times \frac{1}{1}$.

Fig. 2. *Ctenacanthus longinodosus*, sp. nov. Kinderhook Limestone; Mississippi Valley. Basal portion of spine referred to the first dorsal fin. Original preserved in the U. S. National Museum. (Cat. No. 3393). $\times \frac{1}{1}$.

Fig. 3. *Acanthodes marshi* (?), sp. nov. Coal Measures; Mazon Creek, Illinois. Fin belonging presumably to a young individual of same species as shown in Plate 6, Figure 3, with attached spine and calcified fin-membrane. Original preserved in Yale Museum. $\times \frac{1}{1}$.

PLATE 6.

Fig. 1. *Ctenacanthus lucasi*, sp. nov. Kinderhook Limestone; Mississippi Valley. Basal portion of spine referred to the first dorsal fin. Original preserved in the U. S. National Museum. (Cat. No. 4844). $\times \frac{1}{1}$.

Fig. 2. *Ctenacanthus decussatus*, sp. nov. Kinderhook Limestone; Mississippi Valley. Proximal portion of spine referred to the first dorsal fin. Original preserved in the U. S. National Museum. (Cat. No. 4846). $\times \frac{1}{1}$.

Fig. 3. *Acanthodes marshi*, sp. nov. Coal Measures; Mazon Creek, Illinois. Impression of nearly complete pectoral fin preserved in counterpart, showing fin-spine and actinotrichia, but without supporting basal element. Original in Yale University Museum. $\times \frac{1}{1}$.

PLATE 7.

Fig. 1. *Acanthodes marshi*, sp. nov. Coal Measures; Mazon Creek, Illinois. Nodule containing a portion of the dermal covering (shagreen), the granules of which are preserved in their natural arrangement, and present the structure shown in Fig. 2. Original in Yale University Museum. $\times \frac{1}{1}$.

Fig. 2. *Acanthodes marshi*, sp. nov. Enlarged drawing of some of the shagreen granules from the type-specimen shown in Fig. 1. $\times \frac{8}{1}$.

Fig. 3. *Ctenacanthus solidus*, sp. nov. Kinderhook Limestone; Mississippi Valley. Proximal portion of spine referred to the second dorsal fin. Original preserved in the U. S. National Museum. (Cat. No. 4843). $\times \frac{1}{1}$.

PLATE I.

HELIOTYPE CO., BOSTON.

HELIOTYPE CO., BOSTON.

2

1

HELIOTYPE CO., BOSTON.

HELIOTYPE CO., BOSTON.

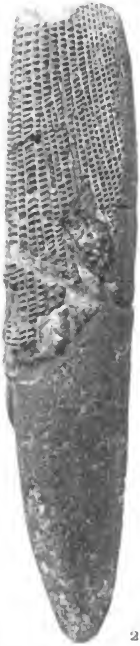
1

2

3

HELIOTYPE CO., BOSTON.

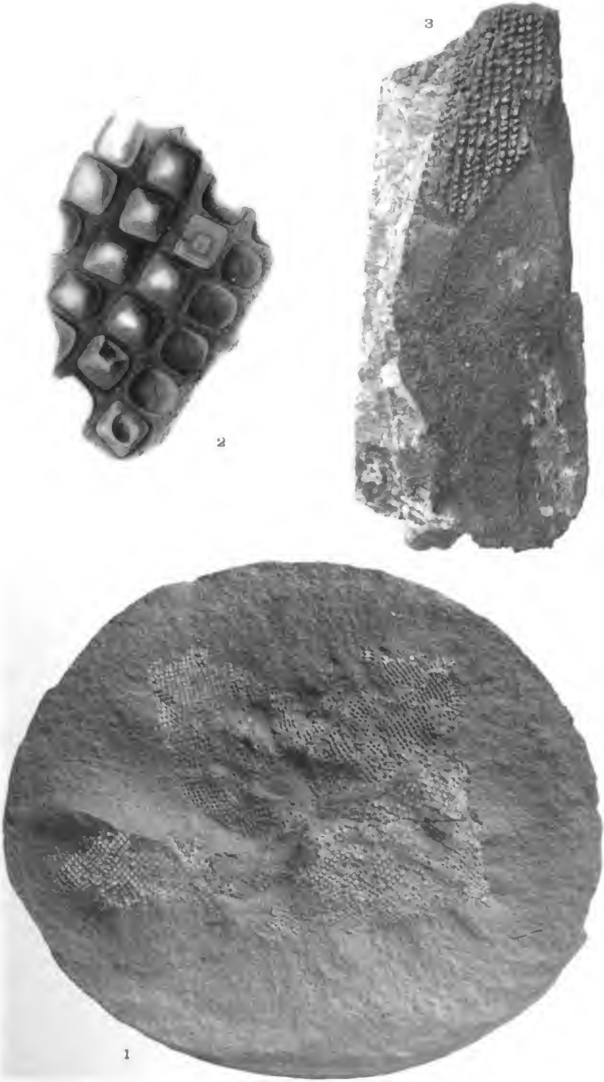
1



2

3

HELIOTYPE CO., BOSTON.



HELIOTYPE CO., BOSTON.

Bulletin of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. XXXIX. No. 4.

ILLUSTRATIONS OF ODONATA: — ARGIA.

By Hermann A. Hagen.

WITH A LIST AND BIBLIOGRAPHY OF THE SPECIES.

By Philip P. Calvert.

With Two Plates.

CAMBRIDGE, MASS., U. S. A.:
PRINTED FOR THE MUSEUM.
November, 1902.

No. 4. — *Illustrations of Odonata: Argia.* By HERMANN A. HAGEN. *With a list and bibliography of the species.* By PHILIP P. CALVERT.[1]

THE illustrations herewith presented require some words of explanation. De Selys and Hagen intended publishing a Monograph of the Agrioninæ, following a Synopsis of this subfamily, as they had for the Calopteryginæ and the Gomphinæ. The Synopsis appeared in instalments from 1860 to 1877. Hagen made drawings for the Monograph which was never published, if indeed it ever was written. These, before his death, were given to his friend and successor in the Museum of Comparative Zoölogy, Mr. Samuel Henshaw. Some of these drawings — those referring to the "grande genre Argia" — have recently been lent to the present writer to be used in the study of material for the Odonate part of the Biologia Centrali-Americana. So useful have they thus proved, so desirable does it seem that others should have the opportunity of using them, that they are here published.

If justification were needed for this proceeding, it may be found in these words of De Selys from the Synopsis of Argia, page 381:

> "De grandes difficultés se présentent pour donner les diagnoses des quarante-six espèces américaines, dont plusieurs sont très-voisines les unes aux autres. Les appendices anals des mâles et les lames du devant du thorax des femelles fournissent, il est vrai, pour la plupart, des caractères positifs; mais ils eussent rendu les diagnoses très-longues, et ces organes ne pouvent être bien vus qu'avec un certain grossissement, j'ai cherché dans les diagnoses de ce Synopsis, à me passer de ces caractères, qui seront réservés pour une monographie spéciale."

As to the figures themselves, the original sheets on which they were made bear the signature "H. Hagen del. 1864." As far as known, they were executed without the aid of a camera lucida. It may be admitted that they are not in all cases perfectly satisfactory, due partly to the fact that the structures they depict were not sufficiently spread apart to be clearly seen, as in Plate 2, Figs. 6 *a*, 14 *a*. It must also be borne

[1] The second-named author is responsible for the entire *text* of this article.

in mind by those using them that the apparent shape of the appendages of the males depends very largely on the particular angle at which they are viewed, and that the appendages themselves are capable of a considerable degree of rotation. The seeming differences between the two figures of *Argia tibialis*, Plate **2**, Figs. 7, 7 *a* and 8, 8 *a*, are readily explained in this way, as any one who will compare them with a male of this species may convince himself. Yet no one who has attempted the study of this difficult genus will question the value of the aid which these figures offer in elucidating the species all too briefly described in the Synopsis of 1865, remembering also that their originals are scattered through several museums of Europe and America. The arrangement of these illustrations on the plates has been chiefly guided by two ideas: to place similar shapes near together for ease of comparison, and to associate species which from personal knowledge are believed to be related.

It has been thought desirable to accompany these figures with a list and bibliography of all the known species of this group. The list has been arranged alphabetically for convenience' sake, since the writer has too little acquaintance with the South American species to attempt to place them in their proper relationships, while, on the other hand, for reasons given elsewhere, he cannot subscribe to the classification employed in the Synopsis of 1865. It is hoped that the bibliography embraces references to all descriptions and figures, but mere locality lists are not necessarily included. The distribution of each species is given in a general way; details will be found in the authors quoted. Two works which together contain descriptions of all the known species are cited in abbreviations. These are: De Selys-Longchamps, Synopsis des Agrionines, 5me légion: Agrion, Le grand genre Argia (Bulletin Acad. Roy. Belg. — 2 — XX., pp. 375–417, 1865), which is quoted simply as "Argia;" since the paging of the separate copy is different, the page number of this latter is also given, but in parentheses ( ). While this Synopsis is published as under the authorship of De Selys, many of the descriptions were written by Hagen, and in such cases due credit is given to the latter. The other work is Calvert: Odonata in Biologia Centrali-Americana, Neuroptera, pp. 17 *et seq.*, London, 1901–02, here shortened to "B. C. A."

As far as possible, the present location of the types of each species is given from personal knowledge and from the literature.

The two closely related genera *Hyponeura* and *Onychargia* have been included.

LIST AND BIBLIOGRAPHY OF SPECIES.

HYPONEURA.

SELYS, Monog. Calopt., p. 275 (1854); Argia, p. 381 (9), (1865). HAGEN, Syn. Neur. N. Am., p. 95 (1861). KIRBY, Cat. Odon., p. 137 (1890). CALVERT, B. C. A., p. 65 (1901).

Type: *H. funcki.*

H. funcki.

SELYS, Monog. Calopt., p. 275 (1854); Argia, p. 381 (9) (1865). CALVERT, B. C. A., p. 67 (1901). ♂ ♀.
Agrion lugens, HAGEN, Syn. Neur. N. Am., p. 95 (1861).

Hab.: Mexico, Guatemala, Colombia. Types in Coll. Selys.

H. lugens.

(Plate 2, Fig. 22.)

Agrion lugens HAGEN, Syn. Neur. N. Am., p. 95 (1861).
Hyponeura lugens SELYS, Argia, p. 382 (10) (1865). CALVERT, B. C. A., p. 66 (1901). ♂ ♀.

Hab.: New Mexico, Arizona, Mexico. Type ♀ in M. C. Z.[1]

ARGIA.

RAMBUR, Névr., p. 254 (1842). SELYS [and HAGEN] Argia, p. 382 (10) (1865). KIRBY, Cat. Odon., p. 137 (1890). CALVERT, B. C. A., p. 67 (1901).

Type: *A. fumipennis.*

A. adamsi.

CALVERT, B. C. A., pp. 70, 80, pl. iv. f. 35, 35 a (apps. ♂) (1901–'02). ♂.

Hab.: Panama. Types in Colls. Adams, Godman.

A. agrioides.

CALVERT, Proc. Calif. Acad. Sci. (2), iv. p. 476, pl. xv. f. 14 (apps. ♂) (1895); B. C. A., pp. 72, 74, 98, pl. iv. ff. 26 (mest. lam. ♀), 62, 62 a (apps. ♂) (1901–'02). ♂ ♀.

Hab.: California, Baja California, Arizona, Texas, Nuevo Leon (Mexico). Types in Colls. Calif. Acad. Sci. and Calvert.

[1] Abbreviation for Museum of Comparative Zoölogy, Cambridge, Mass.

Var. nahuana.

CALVERT, B. C. A., pp. 72, 74, 99, pl. iv. f. 62 ss (apps. ♂) (1901–'02). ♂ ♀.

Hab.: Mexico. Types in Colls. Calvert, Adams, McLachlan, etc.

A. albistigma.

(Plate 2, Figs. 14, 14 *a*.)

HAGEN in SELYS, Argia, p. 402 (30) (1865). ♂ ♀.

Hab.: Montevideo. Types in M. C. Z.

A. apicalis.

(Plate 2, Figs. 21, 21 *a*, 21 *b*.)

Agrion apicalis SAY, Jour. Acad. Nat. Sci. Phila., viii. p. 410 (1839). HAGEN, Syn. Neur. N. Am., p. 91 (1861).
Argia apicalis SELYS, Argia, p. 414 (42) (1865). CALVERT, Trans. Am. Ent. Soc., xx. p. 233 (1893). KELLICOTT, Odon. Ohio, p. 26 (1899). WILLIAMSON, 24 Rep. Geol. Ind., p. 264, pl. vii. f. 9 (apps. ♂) (1900). ♂ ♀.

Hab.: Maine to Virginia, west to Michigan and Kansas and south to Texas. Type of Say supposedly lost, of Hagen in M. C. Z.

A. barretti.

CALVERT, B. C. A., pp. 71, 87, pl. iv. ff. 46, 46 s (apps. ♂) (1901-'02). ♂.

Hab.: Nuevo Leon (Mexico). Type in Coll. Calvert.

A. bipunctulata.

(Plate 2, Figs. 19, 19 *a*.)

Agrion bipunctulatum HAGEN, Syn. Neur. N. Am., p. 90 (1861).
Argia bipunctulata SELYS, Argia, p. 415 (43) (1865). CALVERT, Trans. Am. Ent. Soc., xx. p. 234 (1893). ♂ ♀.
Argia bipustulata KIRBY, Cat. Odon., p. 139 (1890).

Hab.: New York to Florida (specimens from North Carolina, by Morrison, are in the M. C. Z.).

Types in M. C. Z.

A. calida.

(Plate 1, Figs. 13, 13 *a*.)

Agrion calidum HAGEN, Syn. Neur. N. Am., p. 93 (1861) (♂ only).
Argia calida SELYS, Argia, p. 390 (18) (1865). CALVERT, B. C. A., p. 75 (1902). ♂.

Hab.: Tampico (Mexico). Types ♂ in M. C. Z.

A. chelata.

CALVERT, B. C. A., pp. 71, 88, pl. iv. ff. 47, 47 a (apps. ♂) (1901–'02). ♂.

Hab.: Irazu (Costa Rica). Type in Coll. R. McLachlan, London.

A. Claussenii.

(Plate 2, Figs. 1, 1 a.)

SELYS, Argia, p. 386 (14) (1865). ♂ ♀.

Hab.: Minas Geraes (Brazil). Types in Colls. Selys, M. C. Z.

A. collata.

(Plate 2, Fig. 10 a.)

SELYS, Argia, p. 395 (23) (1865). ♂ ♀.

Hab.: Para (Brazil), Surinam. Types ♂ in Coll. Selys, ♀ in Mus., Berlin.

A. concinna.

(Plate 2, Figs. 16, 16 a.)

Agrion concinnum RAMBUR, Névr., p. 270 (1842).
Argia concinna SELYS, Argia, p. 391 (19) (1865). ♂ ♀.

Hab.: Cape of Good Hope. Types in Coll. Selys. No one appears yet to have confirmed or disproven this anomalous habitat.

A. croceipennis.

(Plate 2, Figs. 4, 4 a.)

SELYS, Argia, p. 393 (21) (1865). ♂ ♀.

Hab.: Brazil. Types in Coll. Selys.

A. cupraurea.

CALVERT, B. C. A., pp. 71, 85, pl. iv. ff. 24 (mest. lam. ♀), 42 (apps. ♂) (1901–'02). ♂ ♀.

Hab.: Panama, Venezuela. Types in Coll. Calvert.

A. cuprea.

(Plate 1, Figs. 8, 8 a.)

Agrion cupreum Hagen, Syn. Neur. N. Am., p. 96 (1861).
Argia cuprea Selys, Argia, p. 407 (35) (1865). Calvert, B. C. A., p. 84, pl. iv. ff. 22 (mest. lam. ♀), 41, 41 s (apps. ♂) (1902). ♂ ♀.
Nec. *A. cuprea* Calvert, Proc. Calif. Acad. Sci. (2), iv. p. 479 (1895).

Hab.: Mexico, Guatemala. Type in M. C. Z.

A. deami.

Calvert, B. C. A., pp. 71, 90, pl. iv. ff. 13 (mest. lam. ♀), 52, 52 s (apps. ♂) (1901–'02). ♂ ♀.

Hab.: Mexico. Types in Colls. Adams, Deam.

A. difficilis.

Selys Argia, p. 413 (41) (1865). Calvert, B. C. A., p. 84, pl. iv. f. 15 (mest. lam. ♀) (1902). ♀.

Hab.: Panama, Venezuela, Ecuador, Peru. Type in Coll. Selys.

A. dimissa.

(Plate 2, Fig. 9 a.)

Selys, Argia, p. 388 (16) (1865). ♂ ♀.

Hab.: Tijuca (Brazil). Types in Coll. Selys.

A. eliptica.

(Plate 1, Figs. 15, 15 a.)

Selys, Argia, p. 393 (21) (1865). ♂. (♀ ?).

Hab.: Brazil. Type in Coll. Selys.

A. extranea.

(Plate 1, Figs. 6, 6 a.)

Agrion extraneum Hagen, Syn. Neur. N. Am., p. 92 (1861).
Argia extranea Selys, Argia, p 399 (27) (1865). Calvert, Proc. Calif. Acad. Sci., (3), Zool. i. p. 380, pl. xxv. f. 8 (apps. ♂) (1899); B. C. A., p. 92, pl. iv. ff. 3, 4 (mest. lams. ♀), 56, 56 s, 56 i, 56 ii (apps. ♂) (1902). ♂ ♀.
? *Argia variabilis* Selys, Argia, p. 406 (34) (1865) (♀ only).

Hab.: Mexico, Guatemala, Costa Rica, Colombia, Guiana. Type in M. C. Z.

A. fissa.

(Plate 2, Figs. 13, 13 *a*.)

SELYS, Argia, p. 401 (29) (1865). CALVERT, Proc. Calif. Acad. Sci. (3), Zool. i. p. 381, pl. xxv. f. 11 (apps. ♂) (1899); B. C. A., p. 89, pl. iv. ff. 12 (mest. lam. ♂), 50, 50 s (apps. ♂) (1902). ♂ ♀.

Hab.: Mexico, Guatemala, Costa Rica, Colombia. Types in Coll. Selys.

A. fumigata.

SELYS, Argia, p. 394 (22) (1865) ♀.

Hab.: Essequibo (Guiana). Type in Mus. Copenhagen.

A. fumipennis.

(Plate 1, Figs. 18, 18 *a*, 18 *b*, 18 *c*.)

Agrion fumipenne BURMEISTER, Handb. Ent., ii. p. 819 (1839). HAGEN, Syn. Neur. N. Am., p. 97 (1861). CALVERT, Trans. Am. Ent. Soc., xxv. p. 38 (1898).
Argia fumipennis SELYS, Argia, p. 403 (31) (1865). ♂ ♀.
Argia obscura RAMBUR, Névr., p. 256, pl. viii. f. 1 (entire insect) (1892).

Hab.: Kentucky, Georgia, Florida. Type ♀ in M. C. Z.

A. funebris.

(Plate 1, Figs. 4, 4 *a*.)

Agrion funebre HAGEN, Syn. Neur. N. Am., p. 92 (1861).
Argia funebris SELYS, Argia, p. 398 (26) (1865). CALVERT, B. C. A., p. 97, pl. iv. f. 59 (1902). ♂.

Hab.: Mexico. Type in M. C. Z.

A. harknessi.

CALVERT, Proc. Calif. Acad. Sci. (3), Zool. i. p. 378, pl. xxv. f. 6 (apps. ♂) (1899); B. C. A., p. 87, pl. iv. ff. 21 (mest. lam. ♀), 45, 45 i (apps. ♂) (1902). ♂ ♀.

Hab.: Western slopes of Mexico. Types in Coll. Calif. Acad. Sci.

A. herberti.

CALVERT, B. C. A., pp. 70, 82, pl. iv. ff. 37, 37 s (apps. ♂) (1901–'02). ♂.

Hab.: Guerrero (Mexico). Type in Coll. Godman.

A. immunda.

(Plate 2, Figs. 12, 12 *a*.)

Agrion immundum Hagen, Syn. Neur. N. Am., p. 93 (1861).
Argia immunda Selys, Argia, p. 401 (29) (1865). Calvert, B. C. A., p. 97, pl. iv. ff. 60, 60 a (apps. ♂) (1902). ♂ ♀.
? *Argia vivida* Selys, Argia, p. 406 (34) (1865) (♀ only).

Hab.: Texas, Mexico. Types in M. C. Z.

A. impura.

Rambur, Névr., p. 255 (1842). Selys, Argia, p. 397 (25) (1865). ♂ (♀ ?).

Hab.: North America (?) ♂, Amazon (♀). Types in Coll. Selys.

A. inculta.

(Plate 2, Figs. 18, 18 *a*.)

Hagen in Selys, Argia, p. 400 (28) (1865). ♂.

Hab.: Lima (Peru). Type in Mus. Copenhagen.

A. indicatrix.

Calvert, B. C. A., pp. 70, 73, 82, pl. iv. ff. 8 (mest. lam. ♀), 38, 38 a (apps. ♂) (1901–'02). ♂ ♀.
? *Argia tinctipennis* Kirby, Ann. Mag. N. H., (7) iii. p. 371 (1899).

Hab.: Southern Mexico, Nicaragua. Types in Colls. Godman and U. S. Nat. Mus.

A. infumata.

(Plate 1, Figs. 11, 11 *a*.)

Selys, Argia, p. 392 (20) 1865. ♂ ♀.

Hab.: Para. Types in Coll. Selys.

A. insipida.

(Plate 1, Figs. 3, 3 *a*.)

Hagen in Selys, Argia, p. 389 (17) (1865). Kirby, Ann. Mag. Nat. Hist. (6), xiv. p. 268 (1894). ♂ (♀ ?).

Hab.: Guiana, St. Vincent, and Grenada (West Indies). Type in M. C. Z.

A. jocosa.

SELYS, Argia, p. 408 (36) (1865). ♂.

Hab.: Bogota. Type in M. C. Z.

A. kurilis.

HAGEN in SELYS, Argia, p. 400 (28) (1865). ♀.

Hab.: Kurile Is. Type in M. C. Z.

A. lacrymans.

Agrion lacrymans HAGEN, Syn. Neur. N. Am., p. 95 (1861).
Argia lacrymans SELYS, Argia, p. 386 (14) (1865). CALVERT, B. C. A., p. 88, pl. iv. ff. 16 (mest. lam. ♀), 49, 49 s (apps. ♂) (1902). ♂ ♀.

Hab.: Mexico. Types ♀ in M. C. Z.

A. lilacina.

(Plate 2, Figs. 17, 17*a*.)

SELYS, Argia, p. 405 (33) (1865). ♂ ♀.

Hab.: Brazil. Types in Coll. Selys.

A. medullaris.

(Plate 1, Figs. 2, 2*a*.)

HAGEN in SELYS, Argia, p. 412 (40) (1865). ♂. CALVERT, B. C. A., p. 92, pl. iv. ff. 6 (mest. lam. ♀) 54, 54 s (apps. ♂) ? (1902).

Hab.: Bogota. Type in M. C. Z. Calvert, *l. c.*, suggests the identity of this species and *variabilis*.

A. modesta.

(Plate 2, Figs. 5, 5*a*.)

SELYS, Argia, p. 388 (16) (1865). ♂ ♀.

Hab.: Brazil, Trinidad (HART, Ann. Rep. Roy. Botan. Gard., Trinidad, June, 1891, p. 9). Types in Coll. Selys.

A. moesta.

Agrion moestum Hagen, Syn. Neur. N. Am., p. 94 (1861).
Argia moesta Selys, Argia, p. 384 (12) (1865). Calvert, B. C. A., p. 76, pl. iv. ff. 20 (mest. lam. ♀), 29, 29 s (apps. ♂) (1902). ♂ ♀.

Hab.: Texas, Arizona, Northern Mexico. Types in M. C. Z.

Var. putrida.

(Plate 2, Figs. 15, 15 *a*.)

Agrion putridum Hagen, Syn. Neur. N. Am., p. 96 (1861).
Argia putrida Selys, Argia, p. 385 (13), 1865. Calvert, Trans. Am. Ent. Soc., xx. p. 232 (1893). Kellicott, Jour. Cincin. Soc. Nat. Hist, xvii. p. 202 (1895); Odon. Ohio, p. 23 (1899). Williamson, 24th Rep. Dept. Geol. Indiana, p. 261, pl. iv. f. 2 (1st leg.), pl. vii. f. 7 (apps. ♂) (1900).

Hab.: Quebec to Virginia, west to Wisconsin and Illinois; Florida, Arkansas, Texas. Types in M. C. Z.

A. mollis.

(Plate 1, Figs. 14, 14 *a*.)

Hagen in Selys, Argia, p. 398 (26) (1865). ♂.

Hab.: Minas Geraes (Brazil). Type in Coll. Selys.

munda = var. vivida, *q. v.*

nahuana = var. agrioides, *q. v.*

A. oculata.

(Plate 1, Figs. 12, 12 *a*.)

Hagen in Selys. Argia, p. 409 (37) (1865). Calvert, B. C. A., p. 81, pl. iv. ff. 11 (mest. lam. ♀), 36, 36 s, 36 i, 36 ii (apps. ♂) (1902). ♂ ♀.

Hab.: Mexico to Venezuela. Type ♂ in M. C. Z.

A. oenea.

Hagen in Selys, Argia, p. 407 (35) (1865). Calvert, Proc. Calif. Acad. Sci., (2) iv. p. 481, pl. xv. ff. 21, 22 (apps. ♂) (1895); B. C. A., p. 85, pl. iv. ff. 10 (mest. lam. ♀), 43, 44, 44 s (apps. ♂) (1902). ♂ ♀.

Hab.: Mexico, Guatemala, Colombia (?) Type ♂ in M. C. Z.

A. optata.

(Plate 1, Figs. 19, 19 *a*.)

HAGEN in SELYS, Argia, p. 390 (18) (1865). ♂.

Hab.: Obi (Mollucess). Type in Mus. Leyden. This species, whose appendages seem to indicate some other relationship than *Argia*, has been suggested to belong to *Onychargia* by SELYS, Ann. Mus. Genova, xiv. pp. 316, 317. One also thinks of the legion Platycnemis, SELYS, near *Coeliccia*, KIRBY (*Trichocnemis* SELYS).

A. orichalcea.

(Plate 1, Figs. 7, 7 *a*.)

HAGEN in SELYS, Argia, p. 408 (36) (1865). ♂ ♀. KIRBY, Ann. Mag. Nat. Hist., (7), iii. p. 371 (1899). CALVERT, B. C. A., pp. 71, 86 (1902).
A. cupreum, var. HAGEN, Syn. Neur. N. Am., pp. 97, 312 (1861).

Hab.: Panama, Venezuela. Types in M. C. Z.

pallens = var. violacea, *q. v.*

A. percellulata.

CALVERT, B. C. A., pp. 70, 72, 74, pl. iv. ff. 5 (mest. lam. ♀), 27 (apps. ♂) (1901–'02). ♂ ♀.

Hab.: Vera Cruz (Mexico). Types in Coll. Godman.

plana = var. vivida, *q. v.*

A. popoluca.

CALVERT, B. C. A., pp. 70, 73, 82, pl. iv. ff. 8 (mest. lam. ♀), 38, 38 s (apps. ♂) (1901–'02). ♂ ♀.

Hab.: Tabasco (Mexico). Types in Coll. Godman.

A. pulla.

(Plate 1, Figs. 16, 16 *a*.)

HAGEN in SELYS, Argia, p. 410 (38) (1865). KIRBY, Ann. Mag. Nat. Hist. (7), iii. p. 371 (1899). CALVERT, Proc. Calif. Acad. Sci. (3), Zool., i. p. 382, pl. xxv. f. 4 (apps. ♂) (1899); B. C. A., p. 79, pl. iv. ff. 33, 33 s, 33 ss (apps. ♂) (1902).

Hab.: Mexico to Venezuela. Types in Colls. M. C. Z., SELYS.

A. putrida = variety of moesta, *q. v.*

A. reclusa.

(Plate 2, Figs. 20 *a*, 20 *b*.)

SELYS, Argia, p. 395 (23) (1865). ♂.

Hab.: Para. Type in Coll. Selys.

A. rhoadsi.

CALVERT, B. C. A., pp. 72, 92, pl. iv. ff. 55, 55 s (apps. ♂) (1901–'02). ♂.

Hab.: Nuevo Leon (Mexico). Type in Coll. Godman.

A. rogersi.

CALVERT, B. C. A., pp. 70, 83, pl. iv. ff. 40, 40 s (apps. ♂) (1901–'02). ♂.

Hab.: Costa Rica. Type in Coll. Godman.

A. sedula.

(Plate 1, Figs. 10, 10 *a*.)

Agrion sedulum HAGEN, Syn. Neur. N. Am., p. 94 (1861).
Argia sedula SELYS, Argia, p. 411 (39) (1865). KELLICOTT, Jour. Cincin. Soc. Nat. Hist., xvii. p. 203 (1895); Odon. Ohio, p. 27 (1899). WILLIAMSON, 24th Ann. Rep. Dept. Geol. Indiana, p. 263 (1900). CALVERT, B. C. A., p. 78, pl. iv. ff. 7 (mest. lam ♀) 32 (apps. ♂) (1902). ♂ ♀.

Hab.: Virginia, Ohio, Indiana, Arkansas, Texas, Arizona, Nuevo Leon (Mexico). Types in M. C. Z.

A. serva.

(Plate 2, Figs. 2, 2 *a*.)

HAGEN in SELYS, Argia, p. 387 (15) (1865). ♂ ♀.

Hab.: Brazil. Types ♂ in M. C. Z., ♀ in Mus. Berlin.

A. sordida.

(Plate 1, Fig. 20; Plate 2, Figs. 3, 3 *a*, 23.)

HAGEN in SELYS, Argia, p. 387 (15) (1865). ♂ ♀.

Hab.: Brazil, Buenos Aires. Types in M. C. Z.

A. tarascana.

CALVERT, B. C. A., pp. 71, 74, 90, pl. iv. ff. 14 (mest. lam. ♀), 51, 51 s (apps. ♂) (1901–'02). ♂ ♀.

Hab.: Mexico. Types in Colls. Godman, U. S. Nat. Mus., Adams, Calvert.

A. tezpi.

CALVERT, B. C. A., pp. 70, 73, 77, pl. iv. ff. 19 (mest. lam. ♀), 31, 31 s (apps. ♂) (1901, '02). ♂ ♀.

Argia cupraea CALVERT, Proc. Calif. Acad. Sci., (2) iv. p. 479, pl. xv. f. 12 (apps. ♂) (1895).

Hab.: Lower California, western slopes of Mexico. Types in Colls. Godman, Calif. Acad. Sci., McLachlan, Calvert.

A. thespis.

(Plate 2, Figs. 11, 11 *a*.)

HAGEN in SELYS, Argia, p. 397 (25) (1865). ♂ ♀.

Hab.: Bahia (Brazil). Types in M. C. Z.

A. tibialis.

(Plate 2, Figs. 7, 7 *a*, 8, 8 *a*.)

Platycnemis tibialis RAMBUR, Névr., p. 241 (1842).

Trichocnemis tibialis SELYS in SAGRA, Ins. Cuba, p. 464 (1857). HAGEN, Syn. Neur. N. Am., p. 72 (1861).

Argia tibialis SELYS, Argia, p. 413 (41) (1865). CALVERT, Trans. Am. Ent. Soc., xx. p. 233 (1893). KELLICOTT, Odon. Ohio, p. 26 (1899). WILLIAMSON, 24th Rep. Dept. Geol. Indiana, p. 263, pl. vii. f. 8 (apps. ♂) (1900).

Agrion fontium HAGEN, Syn. Neur. N. Am., p. 91 (1861).

Agrion binotatum WALSH, Proc. Acad. Nat. Sci. Phila., 1862, p. 387.

Hab.: New Jersey to Florida, west to Michigan and Texas. (Specimens from Morganton, North Carolina, by MORRISON are in the M. C. Z.) Type in Coll. Selys.

A. tinctipennis.

(Plate 2, Figs. 6, 6 *a*.)

SELYS, Argia, p. 396 (24) (1865). ♂ ♀.

A. tractipennis KIRBY, Cat. Odon., p. 136 (1890).

Hab.: Amazon valley. Types in Coll. Selys. See also *A. indicatrix, supra*.

A. tonto.

Calvert, B. C. A., pp. 71, 73, 89, pl. iv. ff. 17 (mest. lam. ♀), 48, 48 s (apps. ♂) (1901, '02). ♂ ♀.

Hab.: Arizona. Types in Coll. Calvert.

A. translata.

(Plate 1, Figs. 9, 9 a.)

Hagen in Selys, Argia, p. 410 (38) (1865). Calvert, 27th Ann. Rep. New Jersey State Board Agric., Suppl., p. 68 (1900); B. C. A., p. 76, pl. iv. ff. 18 (mest. lam. ♀), 30, 30 s (apps. ♂) (1901, '02). ♂ ♀. Graf, Ent. News, xiii. p. 113 (1902).

Hab.: New York to Venezuela. Types in M. C. Z.

A. ulmeca.

Calvert, B. C. A., pp. 70, 73, 80, pl. iv. ff. 9 (mest. lam. ♀) 34, 34 s, 34 i (apps. ♂) (1901, '02). ♂ ♀.

Hab.: Mexico, Honduras. Types in Colls. Calvert, Godman.

A. variabilis.

(Plate 1, Figs. 1, 1 a.)

Selys, Argia, p. 406 (34) (1865) (♂ only). Calvert, B. C. A., p. 91, pl. iv. f. 53 (apps. ♂) (1902). ♂ ♀.

Hab.: Mexico to Costa Rica. Types in Colls. Selys and M. C. Z. See also *A. medullaris* and *A. extranea*, *supra*.

A. violacea.

(Plate 1, Figs. 17, 17 a.)

Agrion violaceum Hagen, Syn. Neur. N. Am., p. 90 (1861).
Argia violacea Selys, Argia, p. 404 (32) (1865). Calvert, Trans. Am. Ent. Soc., xx. p. 233 (1893). Kellicott, Jour. Cincin. Soc. Nat. Hist., xvii. p. 203 (1895), Odon. Ohio, p. 25 (1899). Williamson, 24th Ann. Rep. Dept. Geol. Indiana, p. 262 (1900).

Hab.: Maine to Virginia, west to Michigan and Illinois; Texas, New Mexico. Types in M. C. Z.

Var. pallens.

Calvert, B. C. A., pp. 72, 74, 98, pl. iv. ff. 25 (mest. lam. ♀), 61, 61 s (apps. ♂), (1901, '02).

Hab.: Arizona, Mexico. Types in Colls. Adams, Godman, Deam.

A. vivida.

(Plate 1, Figs. 5, 5 *a*.)

Hagen in **Selys**, Argia, p. 406 (34) (1865) (♂ only). **Calvert**, Proc. Calif. Acad. Sci., (2) iv. p. 478, pl. xv. f. 13 (apps. ♂) 1895; B. C. A., p. 94, pl. iv. ff. 1, 2 (mest. lam. ♀), 57, 57 s, 57 ss (apps. ♀) (1902). ♂ ♀.

Hab.: Montana to Vera Cruz; California, Lower California. Types in M. C. Z. See also *A. immunda*, *supra*.

Var. plana.

Calvert, B. C. A., p. 96, pl. iv. f. 58 (apps. ♂) (1902). ♂ ♀.

Hab.: Arizona, Mexico. Types in M. C. Z.

Var. munda.

Calvert, B. C. A., p. 96 (1902). ♂ ♀.

Hab.: Arizona, Mexico. Types in M. C. Z.

A. wilsoni.

Calvert, B. C. A., pp. 70, 75, pl. iv. ff. 28, 28 s (apps. ♂). (1901, '02). ♂.

Hab.: Guatemala. Type in M. C. Z.

ONYCHARGIA.

Hagen in **Selys**, Argia, p. 416 (44) (1865). **Kirby**, Cat. Odon., p. 139 (1890).

Type: *O. atrocyana*.

O. atrocyana.

(Plate 2, Figs. 24, 24 *a*, 24 *b*.)

Selys, Argia, p. 416 (44) (1865). ♂ ♀.

Hab.: Singapore, Sumatra, Borneo, Ceylon (Kirby). Type in Coll. Selys.

O. flavovittata.

Selys, Mitth. Mus. Dresden, iii. p. 321 (1878); Ann. Mus. Genov., xiv. p. 316 (1879). ♀.

ab.: New Guinea. Type ♀ in Coll. Selys.

O. rubropunctata.

Selys, Mitth. Mus. Dresden, iii. p. 321 (1878); Ann. Mus. Genov. xiv. p. 315 (1879). ♂.

Hab.: New Guinea. Type ♂ in Coll. Selys.

O. vittigera.

Selys, Argia, p. 417 (45) (1865). Ann. Mus. Genova (2), x. p. 508 (1891). Krüger, Stett. Ent. Zeit., 1898, p. 118.

Hab.: Sumatra, Java, Singapore, Birma, Sylhet (India). Type in Coll. Selys.

EXPLANATION OF PLATES.

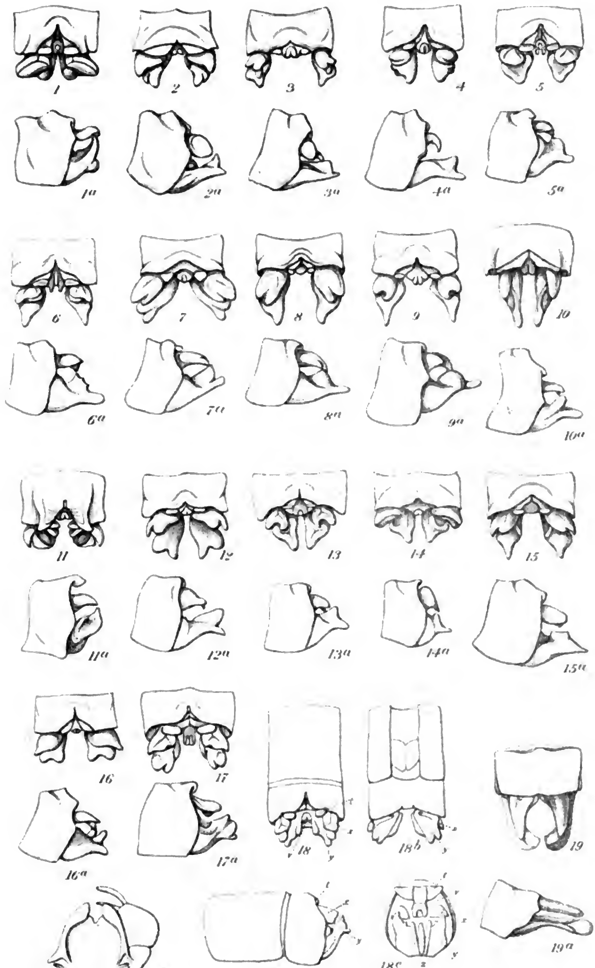
Except where otherwise stated, the figures represent the apex of the abdomen and the appendages of the males. For most species two views are given, a dorsal and a left profile; the former is designated by an arabic numeral, the latter by the same numeral, followed by the letter *a*.

PLATE 1.

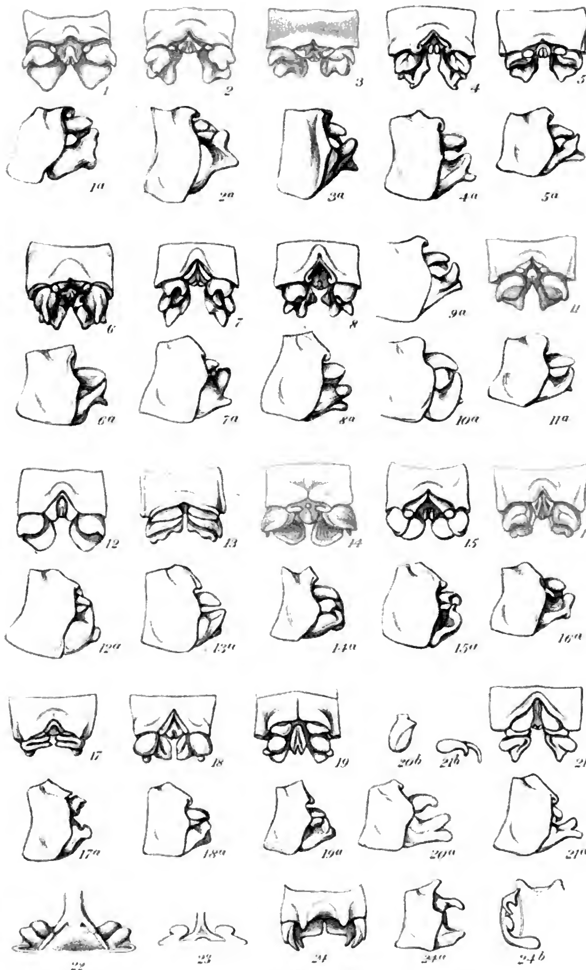
Figs. 1, 1 *a*. Argia variabilis.
Figs. 2, 2 *a*. " medullaris.
Figs. 3, 3 *a*. " insipida.
Figs. 4, 4 *a*. " funebris.
Figs. 5, 5 *a*. " vivida.
Figs. 6, 6 *a*. " extranea.
Figs. 7, 7 *a*. " orichalcea.
Figs. 8, 8 *a*. " cuprea.
Figs. 9, 9 *a*. " translata.
Figs. 10, 10 *a*. " sedula.
Figs. 11, 11 *a*. " infumata.
Figs. 12, 12 *a*. " oculata.
Figs. 13, 13 *a*. " calida.
Figs. 14, 14 *a*. " mollis.
Figs. 15, 15 *a*. " eliptica.
Figs. 16, 16 *a*. " pulla.
Figs. 17, 17 *a*. " violacea.
Figs. 18, 18 *a*. " fumipennis, 18 *b*, ventral, and 18 *c*, posterior view of same: *t*, tubercle on posterior surface of tenth segment; *v*, appendix dorsalis of Heymons (Grundzüge der Entwickelung u. des Körperbaues von Odonaten u. Ephemeriden, Anhang Abhdl. königl. preus. Akad. Wiss. 1896) = "inferior appendage" of authors in the Odonata Anisoptera; *x*, superior appendage of authors (processus caudalis of Heymons); *y*, inferior appendage of authors (appendix lateralis of Heymons); *z*, anal aperture.
Figs. 19, 19 *a*. " optata.
Fig. 20. " sordida, major part of labium.

PLATE 2.

Figs. 1, 1 *a*. Argia Claussenii.
Figs. 2, 2 *a*. " serva.
Figs. 3, 3 *a*. " sordida.
Figs. 4, 4 *a*. " croceipennis.
Figs. 5, 5 *a*. " modesta.
Figs. 6, 6 *a*. " tinctipennis.
Figs. 7, 7 *a*. " tibialis (fontium).
Figs. 8, 8 *a*. " " (binotatum).
Fig. 9 *a*. " dimissa.
Fig. 10 *a*. " collata.
Figs. 11, 11 *a*. " thespis.
Figs. 12, 12 *a*. " immunda.
Figs. 13, 13 *a*. " fissa.
Figs. 14, 14 *a*. " albistigma.
Figs. 15, 15 *a*. " putrida (= variety of moesta).
Figs. 16, 16 *a*. " concinna.
Figs. 17, 17 *a*. " lilacina.
Figs. 18, 18 *a*. " inculta.
Figs. 19, 19 *a*. " bipunctulata.
Fig. 20 *a*. " reclusa; 20 *b*, dorsal view of a single superior appendage.
Figs. 21, 21 *a*. " apicalis; 21 *b*, end view of a single superior appendage.
Fig. 22. Hyponeura lugens ♀ "les lames du devant du thorax" (= mesostigmal laminae of Calvert).
Fig. 23. Argia sordida ♀, ibid.
Figs. 24, 24 *a*. Onychargia atrocyana; 24 *b*, end view of same showing the appendages of the left side only.



H.A. Hagen del 1864 B. Meisel lith Boston



H.A. Hagen del. 1864

B. Meisel, lith. Boston

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CRABS FROM THE MALDIVE ISLANDS.

By Mary J. Rathbun.

With One Plate.

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No. 5. — *Crabs from the Maldive Islands.*

By Mary J. Rathbun.

This collection, aside from a few land crabs and swimming crabs taken at the surface, was obtained in the lagoons of the Maldive atolls in depths of from sixteen to thirty fathoms by the expedition of Alexander Agassiz in 1901–1902. The majority come from Nallandu, Miladummadulu Atoll. Of a total of twenty-eight species, six species seem to be new. Major Alcock has described nearly all the known forms in his "Materials for a Carcinological Fauna of India;" therefore the references to synonymy are not repeated here except where different conclusions have been reached as to the identity of species.

It will be noted that our list furnishes several additions to the Land Crustaceans, Portunidæ, and Xanthidæ given by Borradaile in Gardiner's Fauna and Geography of the Maldive and Laccadive Archipelagoes, I. 1901–1902.

The drawings were made by Miss A. A. McKnew.

OCYPODIDÆ.

Ocypode ceratophthalma (Pallas).

Ocypoda ceratophthalma Alcock, Journ. Asiatic Soc. Bengal, LXIX. 345, 1900, and synonymy.

Ocypode ceratophthalma Borradaile, Fauna Maldive Arch., I. part I. pp. 67 and 96, 1901.

Male, December 23; 2 young. Kolumadulu, December 30; 9 young.

Uca tetragonon (Herbst).

Gelasimus tetragonum Alcock, Journ. Asiatic Soc. Bengal, LXIX. 357, 1900, and synonymy.

Male, December 23; 5 males.

This species is subject to considerable variation in the following directions: — The front may be an oblong lobe, as figured by Milne Edwards,[1] or may be

[1] Ann. Sci. Nat. (3), XVIII. pl. III. fig. 9, 1852.

triangular and subacute, as represented by de Man;[1] the outer margin of the beveled edge is more or less spatuliform. The granular line defining the lateral margin may be present for two-thirds the length of the margin or may be evident only near the antero-lateral angle, without regard to sex. In all the specimens I have examined (27 from 9 localities), the granules of the carpus of the large claw, though small, are visible to the naked eye. The inner surface of the palm is more or less coarsely granulate; the immobile finger more or less strongly curved.

The color of the Maldive examples in alcohol is dark green or blue, with patches of yellow speckled with mulberry at the antero-lateral angles; large cheliped yellow with large brick-red patch at base of pollex; smaller cheliped and legs light mulberry.

Macrophthalmus verreauxi Milne Edwards.

Macrophthalmus verreauxi Alcock, Journ. Asiatic Soc. Bengal, LXIX. 377, 1900, and synonymy.

Gan Island, Addu Atoll, at anchorage, 20 fathoms, January 6; one female, 13.5 mm. wide, and 9.1 mm. long, in which the eyes project beyond the carapace for *more than half* ($\frac{67}{100}$) of their length.

Goneplax maldivensis, sp. nov.

Figs. 3-5.

The length of the carapace is nearly two-thirds of its greatest width. The lateral margins are provided with a strong acute tooth at their anterior fourth, which projects outwardly beyond the antero-lateral angle.

Front wider than orbit, margin sinuous, with a shallow median tooth and a notch at the outer angle in which the antenna is lodged; an impressed line just above the margin.

The supra-orbital margin is sinuous and slopes backward and outward; its outer angle is blunt.

The posterior width of the carapace is nearly three-fourths of the fronto-orbital width.

The surface is punctate under the lens, and closely covered with finer wrinkles. The H-shaped depression in the centre is very shallow.

The eyes almost attain the outer angle of the orbit, the cornea is light-colored in alcohol, and on the under side extends one-half the length of the stalk.

The lower margin of the orbit has a shallow lobe near its middle.

The antero-external angle of the merus of the outer maxillipeds is produced, the anterior margin is excavate.

[1] Notes Leyden Mus., XIII. pl. II. fig. 6, 1891.

The chelipeds are massive, unequal; the larger one is about twice as long as the carapace. The upper margin of the merus has a few denticles and a blunt subterminal tooth; the posterior margin and inferior surface are crossed by a subterminal groove. The inner angle of the carpus forms a blunt, almost rectangular tooth. The palm is nearly as wide as the length of its upper margin; the dactylus is shorter than that margin in the larger cheliped, and longer in the smaller one. The lower margin of the propodus has a shallow sinus between palm and finger. The fingers are broad, white, not gaping, occludent margins irregularly dentate, tips crossing, outer and inner surface each with two lines of larger punctæ.

The surface of the chelipeds is similar to that of the carapace except that the fine wrinkles are interrupted by minute transverse irregular smooth patches.

The merus joints of the ambulatory legs are devoid of a spine on the upper margin. The propodus and dactylus of the last pair are considerably shorter and broader than in the three preceding; the propodus is wider than half of its length measured on the anterior margin; the dactylus is straight, not curved, on its anterior margin.

The first segment of the abdomen of the male is hidden under the carapace; the second is narrowed at the sides and does not fully cover the sternum; the third reaches the coxæ of the fifth pair of legs; the remaining segments are very narrow, the terminal one much longer than broad.

Dimensions. — Length of carapace, 5.1 mm.; width at exorbital angles, 7.5 mm.; greatest width, 7.8 mm.; posterior width, 5.5 mm.; width of front between the antennal notches, 2.5 mm.; width of front between the supraorbital margins, 3.4 mm.

Type locality. — Gan Island, Addu Atoll, at anchorage, 20 fathoms, January 6; one male.

This species differs from *G. rhomboides* (Linnæus) of Europe, in its wider front and shorter eyes, in the carapace being widest at the line of the lateral teeth, in the absence of a spine from the legs, in the much narrower abdomen of the male.

GRAPSIDÆ.

Metasesarma rousseauxi Milne Edwards.

Metasesarma rousseauxii Alcock, Journ. Asiatic Soc. Bengal, LXIX. 427, 1900, and synonymy.

Metasesarma rousseauxi Borradaile, Fauna Maldive Arch., I. part I. pp. 68 and 97, 1901.

Marco, Fadiffolu Atoll, at anchorage; one male, one female with ova. In the male, 9.2 mm. long by 10.2 mm. wide, the fingers when apposed, gape except at the tips.

GECARCINIDÆ.

Epigrapsus politus Heller.

Epigrapsus politus Alcock, Journ. Asiatic Soc. Bengal, LXIX. 443, 1900, and synonymy.

Marco, Fadiffolu Atoll, at anchorage; one small male 7.8 mm. long and 9.5 mm. wide, in which the lateral tooth is faintly indicated.

PALICIDÆ.

Palicus jukesii (White).

Palicus jukesii Alcock, Journ. Asiatic Soc. Bengal, LXIX. 451, 1900, and synonymy. Calman, Trans. Linn. Soc. London (2), Zool., VIII. 29. pl. I. figs. 9–13, 1900.

Hanimadu, Tiladummati Atoll, at anchorage, 16 fathoms, January 19; one female with ova.

Nallandu Island, Miladummadulu Atoll, at anchorage, 24 fathoms, January 18; one immature male.

Palicus contractus, sp. nov.

Figs. 7–8.

Carapace wider anteriorly than posteriorly, and about as long as its width measured between the bases of the third and fourth pairs of legs.

Surface thrown into five transverse wrinkles; the first depression runs directly across the carapace just behind the orbits; the second is the cervical suture; the third is parallel to, and not far from, the second, the fourth is behind the cardiac region. There is a short deep longitudinal depression either side of the mesogastric area. The surface is covered with scabrous granules which are larger on the more elevated portions.

Front cut into two broad rounded lobes. Antero-lateral border with three teeth, including the orbital angle, the third rudimentary. Second tooth projecting laterally more than the first. Behind the second tooth, the margins are sinuous and convergent. Posterior border raised, entire.

Upper border of the orbit with two notches, the inner one the deeper; anterior margins of inner and outer orbital angles concave; lower border with two broad and deep notches. The end of the basal joint of the antenna forms a large lobe visible in a dorsal view, either side of the front. There are three lobules on the eye-stalk, and a large bilobed one at the antero-external angle of the buccal cavern. The two ridges on the ischium of the outer maxillipeds are further apart than in *P. jukesii.*

The chelipeds of the immature male are equal and very slender, scarcely stouter than the last pair of legs, and about as long as the carapace. The palm is a little shorter than the ischium and nearly twice as long as the fingers, which are bent down, deeply grooved, and meet throughout their length.

In the first three pairs of legs the merus is stout and broad, with a granular dorsal surface and coarsely and unevenly serrulate edges, the anterior edge ending in a crest-like tooth. The carpus is dorsally bicarinate and its anterior border has the form of a two-lobed carina. The propodus and dactylus are edged with thin sharp carinæ, that on the anterior margin of the carina of the second and third pairs being plumed. The fourth pair are cylindrical and finely granular, the dactylus considerably shorter than the propodus, the latter having a posterior marginal border of setæ.

The first pair of ambulatory legs are a little longer, the fourth pair a little shorter, than the carapace, the second and third pairs about one and a half times as long as the carapace.

In the male all the abdominal terga except the last are transversely carinate, the carinæ of the second and third terga being most conspicuous. Also on either side of the sternum there are two crests, one behind the base of the last pair of legs, the other almost in a line with the third abdominal carina.

Dimensions. — Male, length of carapace, 6.4 mm.; width between outer orbital angles, 6.9 mm.; width between tips of next lateral teeth, 7.7 mm.; width between bases of second and third legs, 6 mm.

Color. — In alcohol there are traces of dark speckles; there is a larger circular spot on each protogastric region and each cardiac lobule.

Type locality. — Nallandu, at anchorage, 24 fathoms, January 18; two males, immature.

This species can be separated at sight from all others by the carapace being wider in front than behind.

PILUMNIDÆ.

Carpilodes pediger Alcock.

Carpilodes pediger Alcock, Journ. Asiatic Soc. Bengal, LXVII. 83, 1898. Illus. Zool. Investigator, Crust., part VII. pl. XXXVI. fig. 4, 1899.

Male, at anchorage, January 11; one male.

Nallandu, at anchorage, 24 fathoms, January 18; two females, one with ova.

The specimens are all small, the female with ova measuring 3.7 mm. long and 5.8 mm. wide; its carapace is a light yellowish red in alcohol, with lateral teeth gray and mottlings of gray on the posterior half.

Actæa spinosissima Borradaile.

Actæa spinosissima Borradaile, Fauna Maldive Arch., I. part 3. p. 256. fig. 55, 1902.

Nallandu, at anchorage, 24 fathoms, January 18; two young.

Xanthias alcocki, sp. nov.

Figs. 9–10.

The surface of the carapace is granular, the granules coarse on the anterior and antero-lateral portions, very fine on the posterior part. Fronto-orbital region marked off by a sinuous groove. Regions well delimited. There is a short transverse crest on each epigastric, protogastric, hepatic and anterior branchial region.

The front is marked by a double edge, the lower or true edge not visible in a strictly dorsal view, outer angle very slightly marked. Notches of supra-orbital margin minute.

Antero-lateral margin cut into four teeth besides the inconspicuous outer angle of the orbit; the first and fourth teeth are very small, the second and third of good size, triangular, the tip of the second pointing a little forward, the third directed outward. A subhepatic protuberance is visible between the orbital and the first antero-lateral tooth.

The chelipeds in the female are nearly equal, stout, less than twice the length of the carapace. Outer surface covered with scaly granules. Merus nearly hidden under the carapace, margins finely serrulate. Carpus with a few larger granules. Granules of hand larger above than below, some of them disposed to form longitudinal rows. Fingers rather long, deflexed, grooved, tips crossing; light brown in alcohol, the color on the pollex not reaching quite to the palm; dactylus of right or larger hand with a large tooth at its base.

Ambulatory legs finely granular; upper margins of meral and carpal joints serrulate. Dactyli pubescent, propodal joints sparsely so.

Dimensions. — Length of carapace of female, 3 mm.; width, 4.4 mm.

Type locality. — Nallandu, 24 fathoms, at anchorage, January 18; one mature and one young female.

Pilumnus woodworthi, sp. nov.

Figs. 11–12.

Carapace nearly three-fourths as long as broad, deeply areolated, covered with a short dense pubescence mixed with longer hairs; when this is removed, fine granules may be seen on the anterior portion of the gastric region and towards the antero-lateral margin. The frontal and orbital region is set off by a sinuous groove.

Fronto-orbital width greater than length of carapace; front divided by a deep median notch into two broad oblique rounded lobes having at their outer ends a small triangular tooth.

The superior margin of the orbit has two triangular notches, the outer one much the larger; a broad gap below the outer angle. No subhepatic tooth. Antennal flagellum sparingly fringed with hair.

The lateral margin is cut into three teeth besides the outer orbital; the last one has a spinule at the extremity.

Chelipeds unequal. Chelipeds and legs pubescent and hairy, except the lower distal portion of the larger palm which is bare, and also the extremity of the digits. The surface of the wrist is smooth except toward the inner angle where it is spinulous; the angle itself is tipped by a small spine. The outside of the palms is covered with subacute granules or tubercles arranged largely in rows, and becoming smaller toward the lower margin; similar granules ornament the fingers except towards the end. The thumb is short, in the large cheliped shorter than its height.

The legs are rather broad, pubescent, and beset with long hairs on the margins.

Dimensions. — Length of mature female, 5.4 mm.; width, 7.6 mm.; fronto-orbital width, 6 mm.; lower width of front, 2.9 mm.

Type locality. — Nallandu, at anchorage, 24 fathoms, January 18 ; one female.

This species is near *P. sluiteri* de Man,[1] but is distinguished by its wider carapace, relatively wider across the front and orbits, forming straighter sides, its deeper areolation and shorter immovable finger.

Pilumnus hirsutus Stimpson?

Pilumnus hirsutus STIMPSON, Proc. Acad. Nat. Sci. Phila., X. 37 [34], 1858. Not *P. hirsutus* HASWELL, 1882, nor BORRADAILE, Proc. Zool. Soc. London, 1900, p. 581. pl. XLII. fig. 9, and Fauna Maldive Arch., I. pt. III. 245, 1902.

One young specimen, 3.2 mm. wide, from the centre of Male Lagoon, 30 fathoms (December 26), seems to be nearer *P. hirsutus* than any other species.

The following is Stimpson's description extracted from his unpublished report on the Crustacea of the North Pacific Exploring Expedition:

"Body and feet hirsute above, not very thickly, with setæ of variable but moderate length. Carapax scarcely areolate, broad; proportion of length to breadth, 1: 1.43; surface nearly smooth. Antero-lateral margin short, with four sharp teeth, including the angle of the orbit; no subhepatic tooth. Inferior margin of orbit denticulated. Eyes with rather long peduncles. Front emarginate, with a row of long setæ just above the margin. Chelopoda rather small; larger hand

[1] See Alcock, Journ. Asiatic Soc. Bengal, LXVII. 194, 1898.

irregularly tuberculose above, smooth below; smaller hand (the left one) spinulose above, and sparsely granulose on the outer side; fingers pale brownish.

"Color a clear light brick-red. Beneath pale red; sternum white. Fingers with brown tips. Eyes straw-colored. Dimensions of a female; — length of carapax, 0.31; breadth, 0.43 inch.

"The carapax of the specimen taken at Ousima is more swollen than that of the others, and less hairy; — there are a few tufts of long hairs, 4 or 6 to each tuft; two on the gastric region are most conspicuous.

"De Haan's description of his *P. minutus* (Fauna Japonica, Crust. p. 50) applies very well to our species; but his figure (Pl. III. f. 2) is by no means a good representation of it. The body in that figure is smooth, the feet very slender and little hairy. The postero-lateral margin is represented as convex, while it is rather concave in our species.

"Dredged in the Northern China Sea, from a shelly bottom in twenty fathoms. Also found among dead corals taken from a sandy bottom in 30 fathoms off the east coast of Ousima. A single specimen, probably of this species, was taken at the Bonin Islands."

In 1896, the "Albatross" collected in Hakodate Bay, Japan, 11½ fathoms (station 3656), a single male, 5.5 × 7.3 mm., which is referred here. The lobes of the front are oblique, finely denticulate, and at their outer end there is a small spine. The tubercles of the palms are arranged somewhat in rows and are sharp — rather stout spines than tubercles. Wrists also spinous. The ambulatory legs have a few spines on anterior margin of merus.

The young *Pilumnus* from Male agrees in all respects with the male from Hakodate Bay, as far as its size permits, except that the tubercles of the larger palm extend a little lower down on its outer surface.

I am not sure that this is the *P. hirsutus* of Alcock, described as having frontal lobes shaped as in *P. vespertilio*.

PORTUNIDÆ.

Portunus sanguinolentus (Herbst).

Neptunus sanguinolentus Alcock, Journ. Asiatic Soc. Bengal, LXVIII. 32, 1899, and synonymy.

West of Goadu, Miladummadulu Atoll, surface, January 19; one young male.

Portunus (Xiphonectes) longispinosus (Dana).

Neptunus (Hellenus) longispinosus Alcock, Journ. Asiatic Soc. Bengal, LXVIII. 40, 1899, and synonymy. Borradaile, Fauna Maldive Arch., I. part I. p. 208, 1901.

Male, at anchorage, January 11; one mature female. In this specimen the median sinus of the front is shallower and broader than the submedian.

Two types (♂ and ♀) of Dana's *Xiphonectes longispinosus* are preserved in the Museum of Comparative Zoology. The surface of the carapace is very uneven, the frontal teeth rounded, the intervening sinuses shallow and of equal depth, a well-marked sinus below the outer orbital angle, the inner suborbital angle rounded, the merus of the maxilliped reaches part way along the inner suborbital tooth. Width of male between tips of lateral spines, 14.2 mm., of female, 12.8 mm.

Thalamita oculea Alcock.

Thalamita oculea Alcock, Journ. Asiatic Soc. Bengal, LXVIII. 76 and 91, 1899. Illus. Zool. Investigator, Crust., pt. VIII. pl. XLVIII. figs. 3. 3a, 1900.

Gan Island, Addu Atoll, 20 fathoms, at anchorage, January 6; one immature male.

Nallandu Island, 24 fathoms, at anchorage, January 18; one young.

In the male (5.9 mm. long), the fourth lateral tooth is much smaller than the fifth. That spine on the outer margin of the upper surface of the hand which is remote from the finger, though smaller than the other spines, is well marked. The length and breadth of the sixth abdominal somite are subequal.

In the young specimen the fourth lateral tooth is rudimentary, the fifth is subequal to the third.

? Archias,[1] sp.

Nallandu Island, 24 fathoms, January 18. Two very young specimens, one 2.6 mm. long and 3.2 mm. wide, are not referable to any known species. The carapace is quadrate or Thalamita-like, while the narrow, elongated basal joint of the antenna and the remoteness of the inner suborbital angle from the front, place the species in the neighborhood of Archias, Lupocyclus, and Carupa.

The carapace is somewhat granulous and traversed by two transverse ridges, one across the gastric region, the other further back, connecting the posterior of the lateral teeth. The intra-orbital width is a little over half the width of the carapace; the margin of the front is divided into four shallow lobes, the inner pair about one-third as wide as the outer, and slightly more advanced. Inner supra-orbital angles obscurely defined.

The antero-lateral margins are straight and parallel to each other, cut into 4 subequal, sharp-pointed teeth with a rudiment of another between the last two. The postero-lateral margins are concave and moderately convergent.

The orbits are very large (as also the eyes), with slight dorsal inclination; no fissures visible on the margin. The inner end of the lower margin is angular but not prominent, projecting very little beyond the buccal cavity.

The basal joint of the antenna is more than twice as long as broad, it widens

[1] *Archias* Paulson, Crustacea of the Red Sea, 1875, p. 56.

very slightly towards the distal end, and lies for nearly its whole length in the broad orbital hiatus; the second joint reaches the margin of the front.

The buccal cavity widens considerably at its anterior end. The merus of the outer maxilliped is not dilated at its antero-external angle.

The chelipeds are stouter and not so long as the legs, the arm and the hand of about equal thickness. Three spines on inner border of arm; the customary spine (of good size) at inner angle of wrist, and a few smaller spines on its outer surface; three spines on palm, one at angle of wrist, and two side by side nearer the fingers. Dactylus longer than upper surface of palm.

First three pairs of legs slender, also the basal segments (including the carpus) of the last pair; merus of last pair with a spine toward the end of its lower margin.

It is probable that the adult of this species will prove to have the same relation to Archias that Thalamita has to Charybdis.

CANCRIDÆ.

Kraussia nitida Stimpson.

Fig. 13.

Kraussia nitida Stimpson, Proc. Acad. Nat. Sci. Phila., X. 40 [37], 1858. Miers, Crust. Alert, 235, 1884. ? Calman, Trans. Linn. Soc. London (2), Zool., VIII. 24, 1900. Not *K. nitida* Henderson, Trans. Linn. Soc. London (2), V. 379. pl. XXXVII. fig. 9, 1893, nor Alcock, Journ. Asiatic Soc. Bengal, LXVIII. 98, 1899.

Kraussia integra Borradaile, Fauna Maldive Arch., I. pt. III. p. 270, 1902. Not *K. integra* de Haan.

Nallandu, 24 fathoms, at anchorage, January 18; two males, one female.

Distribution. — North China Sea, lat. 23°, 24 fathoms, and Kagosima Bay, Japan, 20 fathoms (Stimpson). Thursday Island, Torres Straits, 4–5 fathoms (Miers).

A comparison of Stimpson's unpublished figure with that of Henderson seems to indicate two distinct species. The Maldive specimens agree sufficiently with Stimpson's figure. The fronto-orbital width is nearly two-thirds the full width of the carapace, the frontal lobes are subequal and equally produced; in Henderson's species, as represented by his figure and by a specimen in the United States National Museum from Samoa, the fronto-orbital width is only half as great as that of the carapace, the median lobes of the front are much narrower and less advanced than the lateral pair.

In the Samoan specimen of *K. nitida* Henderson (which I will call *K. hendersoni*), a large male, 17.5 mm. long and 20.5 mm. wide, fronto-orbital width 10.6 mm., the outer surface of the palm is faintly rugulose, the dactylus serrulate, the inner angle of the wrist has sharp granules, and the adjacent margin is spinulous, the last three joints of the legs are provided with denticulations. According to Alcock, who may have had small specimens, the chelipeds are quite smooth except for a few granules at the inner angle of the wrist, and the last three joints of the legs are without any denticulations or have only a trace of them on the propodite.

In the Maldive examples of *K. nitida* Stimpson, the surface of the chelipeds and legs is similar to that of *K. hendersoni*, the rugæ of the palm being a little more distinct. The dactyli of the legs are considerably longer and slenderer; in the second pair they are 4 times, in *K. hendersoni* 3 times, as long as wide. Furthermore, in *K. nitida*, the notch below the outer angle of the orbit is more pronounced, the basal antennal joint is narrower, the color of the thumb does not run back on the palm as in *K. hendersoni.*

Dimensions. — Male from Nallandu: Length, 7.7 mm.; width, 8.4 mm.; fronto-orbital width, 5.4 mm.

MAIIDÆ.

Oncinopus aranea DE HAAN.

Oncinopus aranea ALCOCK, Journ. Asiatic Soc. Bengal, LXIV. 183, 1895, and synonymy.

Nallandu, 24 fathoms, at anchorage, January 18; one young male.

Halimus tenuicornis (POCOCK).

Hyastenus tenuicornis ALCOCK, Journ. Asiatic Soc. Bengal, LXIV. 215, 1895, and synonymy. Illus. Zool. Investigator, part VI. pl. XXXIII. fig. 4, 1898.

Nallandu, 24 fathoms, at anchorage, January 18; 2 females (one with eggs).

Halimus agassizii, sp. nov.

Fig. 6.

Carapace oblong-triangular, slightly pointed behind, the regions well-defined, sparsely setose, tuberculated, or spinulous, as follows: — 7 sharp tubercles or spinules disposed in a cross on the gastric region, 3 on the median line, 4 forming a Y on the cardiac region, one near the lateral boundary of that region, one on the intestinal region, 3 spines near the outer margin of the branchial region, 2 smaller spines further in, one marginal hepatic spine. Posterior margin granulate; parallel to it another row of granules.

The rostrum consists of 2 slender slightly divergent spines, which in the male are one-half as long as the carapace proper; margins rough with fine spinules and fringed with setæ.

The angles of the supra-ocular eave are produced, the anterior is acuminate, the posterior acute; between it and the post-ocular lobe there is a small tooth on the orbital margin.

The basal antennal joint has a spine at its anterior outer angle visible from above. The merus of the outer maxillipeds is expanded at the antero-external angle.

The chelipeds and legs are more or less roughened. The chelipeds of the male are a little stouter than the trunk-legs and one and a third times as long as the carapace, enclusive of rostrum. The palm has on its outer face 2 longitudinal furrows which are continued on the fingers; these are gaping for two-thirds their length.

The first ambulatory leg is two and a third times as long as the carapace (rostrum excluded); though longer than the second pair, there is hardly more difference than between the second and third. The fourth leg is missing. The merus joints are armed with 3 or 4 long slender spines, the carpal joints with two. Dactyli very slender and spinulous.

The ridges of the sternum and abdomen are granulated.

Dimensions. — Length of carapace exclusive of horns, 4.7 mm., width, 3.4 mm., length of horns, 2.3 mm.

Type locality. — One male was taken at Nallandu at the anchorage in 24 fathoms, January 18.

The tooth on the superior orbital margin connects this species with the genus Naxioides; the spines on the legs separate it from other species of Halimus.

PARTHENOPIDÆ.

Lambrus (Rhinolambrus) longispinis Miers.

Lambrus (Rhinolambrus) longispinis Alcock, Journ. Asiatic Soc. Bengal, LXIV. 266, 1895, and synonymy.

Centre of Male Lagoon, 30 fathoms, December 26; one female with ova, 7.7 mm. long, 7.2 mm. wide.

Lambrus (Rhinolambrus) bispinosus, sp. nov.

Figs. 1-2.

Carapace nearly as long as wide; 2 strong median spines, one gastric, the other cardiac; a blunt oblique ridge on the branchial region, between which and the gastric and cardiac regions are two pits; postero-lateral angle strongly elevated; irregular granules distributed sparingly on the branchial ridge and between it and the cardiac region, on the slopes of the cardiac region, on the anterior half of the gastric region, hepatic region slightly roughened, a single granule on the genital region. Otherwise the carapace is almost smooth.

The rostrum is broad, prominent, declivous, blunt.

The orbital margin is prominent, above finely crenulate, on the outside fluted and denticulate. The postorbital constriction is strongly pronounced.

The hepatic region is well marked off, its margin is sub-rectangular, with two or three shallow teeth.

The branchial region has on the antero-lateral margin 6 teeth with finely crenulated edges, and on the postero-lateral margin about 4 irregular lobes. The blunt tooth or spine at the extremity of the branchial ridge is the most elevated point of that region, but the carapace is widest at the first tooth outside the ridge.

Posterior margin subentire.

The chelipeds in the adult female are one and a half times as long as the carapace, and unequal. The inner and outer margins of the arm are each bordered by about 8 irregular lobes, of which 2, one at the middle and one at the distal end of the outer margin, are the largest; upper surface with one tubercle and a few granules in a longitudinal series.

The surface of the wrist is rough; there is a prominent lobe at the middle of the outer margin; a tubercle on the inner margin.

The upper surface of the hand has 2 strong laminate lobes near the wrist, the outermost pointing backward and outward, the innermost further from the wrist and directed forward and inward. The inner and outer surfaces are crossed by an obliquely longitudinal line of tubercles of which 2 or 3 are enlarged. Otherwise, except for a few granules, the surface is smooth and punctate. Lower margin of arm and hand denticulate.

The fingers are somewhat gaping when closed, in the larger cheliped, their extreme margins, as well as a carina on the outer surface are granulate; the proximal half of upper margin of dactylus denticulate; occludent margins dentate, 3 large teeth on the pollex of the larger claw.

The ambulatory legs increase in width from the first to the fourth; the first is very slender and about as long as the carapace, and has a few tubercles on the margins, most noticeable on the margins of the merus and the lower margin of the propodus. The second is a little shorter and stouter, with larger tubercles. The third and fourth are bordered by laminiform lobes. The dactyli of all the legs are long, slender, and pubescent.

Dimensions. — Female with ova: Length of carapace, 10.6 mm.; width, 10.9 mm.

Type locality. — Nallandu, 24 fathoms, at anchorage, January 18; one female with ova.

Allied to *L. confragosus* Calman, from which it is readily separated by the strongly upturned branchial angles, the absence of a spine behind the cardiac spine, the wider hepatic lobe, and the presence of only one lobe on the upper outer margin of the hand.

CALAPPIDÆ.

Calappa gallus (Herbst).

Calappa gallus Alcock, Journ. Asiatic Soc. Bengal, LXV. 146, 1896, and synonymy.

Nallandu, 24 fathoms, at anchorage, January 18; one young.

LEUCOSIIDÆ.

Persephona brevimana (Alcock).

Myra brevimana Alcock, Journ. Asiatic Soc. Bengal, LXV. 206, 1896, and synonymy.

Nallandu, 24 fathoms, at anchorage, January 18; one young female.

Persephona darnleyensis (Haswell).

Myra darnleyensis Alcock, Journ. Asiatic Soc. Bengal, LXV. 207, 1896, and synonymy.

Fulidu, 18 fathoms, January 18; one female with ova, 13.4 mm. long, 10.7 mm. broad.

Porcellanella triloba White.

Porcellanella triloba White, in Macgillivray's Voyage H. M. S. Rattlesnake, II. Appendix No. VI. p. 394. pl. V. fig. 2, 1851.[1] Henderson, Challenger Anomura, 112, 1888; Trans. Linn. Soc. London (2), V. 429, 1893.
Porcellana triloba Haswell, Cat. Austral. Crust., 149, 1882.

Nallandu, 24 fathoms, at anchorage, January 18; one small male, with bopyrid parasite lodged in the branchial cavity.

Distribution. — Off Cape Capricorn, East Australia, 15 fathoms (White). Celebes Sea, 10–20 fathoms (Henderson). Port William, Falkland Islands, 5–12 fathoms (Henderson). Rameswaram, India (Henderson).

[1] The title-page bears the date 1852, but the work appeared in December, 1851. See Athenæum, London, Dec. 6, 1851, p. 1280, and Jardine's Contributions to Ornithology in 1851, p. 6.

PAGURIDÆ.

Dardanus, sp.

At Hanimadu, Tiladunmati Atoll, 16 fathoms, at anchorage, a young hermit crab was collected, which approaches very near *Dardanus scabrimanus* (Dana).

The lateral teeth of the front are more advanced than the middle. Eyes stout, two and a half times as long as wide, equalling two-thirds of the width of the front; cornea green in alcohol, and occupying one-third the length of the stalk; eyes surpassing a little the stalk of the outer antennæ, subequal to that of the inner antennæ. Eye scales somewhat obcordate, having a sinus on the middle of the anterior margin.

The claws and legs as well as the body are sparsely clothed with long hair. Claws very unequal. Upper and outer surface of wrist of left cheliped and distal end of arm spinulous; upper margin of wrist and hand spinous; outer face of hand sparingly spinulous and granulous, lower half almost smooth; lower margin with a row of small spines. Fingers broken. Smaller cheliped more spinulous and hairy than the larger.

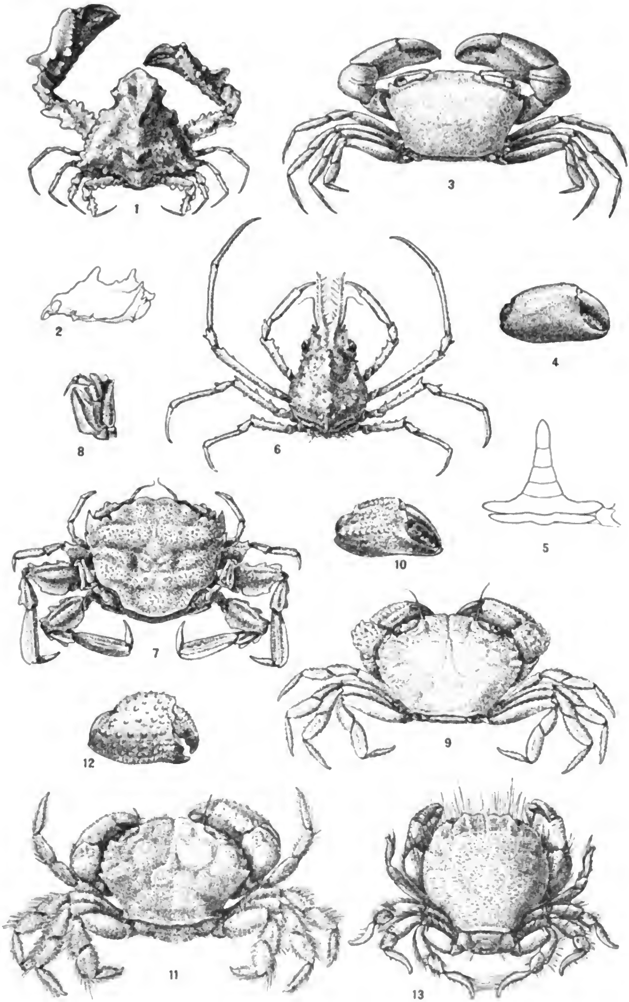
Second and third pairs of feet with the last three segments roughened above, dactyli much longer than propodi, and having a longitudinal groove on the outside. Propodus of left third foot roughest.

Length of carapace, about 4.5 mm.

EXPLANATION OF PLATE.

Fig. 1. *Lambrus (Rhinolambrus) bispinosus*, ♀, $\times 2$.
Fig. 2. " " " ♀, profile, $\times 2$.
Fig. 3. *Goneplax maldivensis*, ♂, $\times 3\frac{1}{3}$.
Fig. 4. " " ♂, outer surface of larger chela, $\times 3\frac{1}{3}$.
Fig. 5. " " ♂, abdomen, $\times 6\frac{2}{3}$.
Fig. 6. *Halimus agassizii*, ♂, $\times 4$.
Fig. 7. *Palicus contractus*, ♂, $\times 3\frac{1}{3}$.
Fig. 8. " " outer maxilliped, $\times 4\frac{1}{3}$.
Fig. 9. *Xanthias alcocki*, ♀, $\times 5\frac{1}{3}$.
Fig. 10. " " ♀, outer surface of right chela, $\times 6\frac{2}{3}$.
Fig. 11. *Pilumnus woodworthi*, ♀, $\times 3\frac{2}{3}$.
Fig. 12. " " ♀, outer surface of larger chela, $\times 3\frac{2}{3}$.
Fig. 13. *Kraussia nitida*, ♂, $\times 2\frac{2}{3}$.

Rathbun, — Maldive Crabs.



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BIRDS AND MAMMALS FROM HONDURAS.

BY OUTRAM BANGS.

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No. 6. — *Birds and Mammals from Honduras.*

By Outram Bangs.

In the early winter of 1902, Mr. W. W. Brown, Jr., started on a short trip to the coast of Honduras. He collected for a few weeks in January, at Ceiba (on some maps Laceiba), situated on the hot coastal plain at about sea level. In February he prepared, with the aid of an assistant, for the exploration of the little known mountain range that extends, parallel with the coast, some twenty miles inland from Ceiba. After a few days' work at Yaruca (1,000 ft.), Mr. Brown had the misfortune to lose his assistant, and though among unfriendly Indians, continued to collect there for a few weeks. He was obliged, however, to abandon his mountain trip.

The birds and mammals secured belong, for the most part, to well-known species; there are, however, a few rare and interesting forms in the series, and the distribution of some of the birds is considerably extended. A complete list of the species collected follows.

BIRDS.

Butorides saturatus Ridg.

One adult ♂; Yaruca. This skin is referable to the form first described from Swan Island.

Micrastur guerilla Cass.

Four specimens, young and adult; Ceiba and Yaruca.

Accipiter bicolor (Vieill.).

One adult ♂; Yaruca.

Morphnus guianensis (Daud.).

One young ♂; Ceiba. This record extends the range of this species from Panama to Honduras.

Tinamus robustus fuscipennis (Salvadori).

One ♀; Yaruca.

Crypturus soui modestus (Cab.).

Two specimens, ♂, ♀; Yaruca.

Heliornis fulica (Bodd.).

Two females; Ceiba.

Actitis macularia (Linn.).

One ♀; Ceiba.

Tringa minutilla Vieill.

One ♂; Ceiba.

Asarcia variabilis (Linn.).

Two males, young and adult; Ceiba.

Columba speciosa Gml.

One ♂; Ceiba.

Columbigallina rufipennis rufipennis (Bp.).

One ♀; Ceiba.

Claravis pretiosa (Ferrari-Perez).

Two males; Ceiba.

Leptotila plumbeiceps Scl. and Salv.

Three specimens, both sexes; Ceiba.

Leptotila vinaceiventris (Ridg.).

Four specimens, both sexes; Yaruca.

Piaya cayana thermophila (Scl.).

Eleven specimens, both sexes; Ceiba and Yaruca.

Crotophaga sulcirostris Swains.

Seven specimens, both sexes; Ceiba and Yaruca.

Amazona autumnalis (Linn.).

Three males; Ceiba.

Pionus senilis (Spix.).

Four specimens, both sexes; Ceiba.

Pionopsittacus haematotis haematotis (Scl. and Salv.).

Three specimens, both sexes; Yaruca.

Salvadori referred the Chiriqui skins in the British Museum to this form, and I followed him in my paper (Auk, 1901, Vol. XVIII., p. 359). On re-examining the specimens, I consider this identification erroneous, and the Chiriqui birds, though somewhat intermediate, belong with the southern form, *P. haematotis coccineicollaris* (Lawr.). All my Chiriqui skins have the characteristic olive-brown markings on the pileum (the northern bird having reddish edges to these feathers). None of my Chiriqui specimens have complete red collars, but all have red feathers scattered through the olive green of the under side of the neck, a characteristic not shown in any northern skin I have examined. The southern form is larger than the northern — strangely enough Salvadori gave no measurements for the southern bird, *P. haematotis coccineicollaris.*

Prionornis carinatus (Du Bus.).

One adult ♂; Ceiba.

Eumomota superciliaris (Sandb.).

One adult ♂; Ceiba.

Momotus lessoni Less.

Seven specimens, both sexes; Ceiba and Yaruca.

Ceryle amazona (Lath.).

One adult ♀; Ceiba.

Ceryle americana septentrionalis Sharpe.

One adult ♂; Yaruca.

Glaucidium griseiceps Sharpe.

Two specimens, ♂ & ♀; Yaruca.

Nyctidromus albicollis (Gml.).

One ♂; Ceiba.

Phaethornis longirostris longirostris (Less. and Delatt.).

One adult ♂; Ceiba.

Amazilia tzacatl dubusi (Bourc. and Muls.).

Six specimens, both sexes; Ceiba and Yaruca.

Amazilia cyanocephala (Less.).

One adult ♀; Yaruca. After studying all the material in Washington, — collections U. S. National Museum and Division of Biological Survey, — I cannot satisfactorily separate by external characters or geographic range the subspecies *A. guatemalensis* Gould. The present example is true *A. cyanocephala*.

Thalurania townsendi Ridg.

One adult ♂; Yaruca. This very distinct species is still a rare bird in collections, and so far as known has a very restricted range.

Heliothrix barroti (Bourc. and Muls.).

Two males; Ceiba and Yaruca.

Trogon melanocephalus Gould.

Seven specimens, both sexes; Ceiba.

Trogon caligatus caligatus Gould.

Five specimens, both sexes; Yaruca. On comparing these and Mexican specimens with skins from Panama, I find that the latter represent a very well-marked subspecies, differing from the more northern bird — true *C. caligatus* —

in being smaller, and in having the belly and under-tail coverts deep orange, (these parts being cadmium yellow in true *C. caligatus*). The Panama bird is *Trogon caligatus concinnus* (Lawr.) type locality, Isthmus of Panama.[1]

Galbula melanogenia Scl.

Two males ; Ceiba and Yaruca.

Rhamphastos brevicarinatus Gould.

Three specimens, both sexes ; Ceiba.

Pteroglossus torquatus (Gml.).

Seven specimens, both sexes ; Ceiba and Yaruca.

Chloronerpes simplex allophyeus,[2] subsp. nov.

Type (and only specimen) from Yaruca, Honduras, 1,000 feet altitude, adult ♂, No. 10,349, Coll. E. A. and O. Bangs, collected Feb. 11, 1902, by W. W. Brown, Jr.

Characters. — Similar to *C. simplex simplex*, but considerably smaller, bill smaller, the throat marked with yellowish instead of plain, the general coloration below richer yellow, the spots on lower neck and breast larger and less round in shape, and the blackish bands on belly narrower.

Color. — Adult ♂, pileum and malar stripe crimson ; auriculars and upper parts yellowish olive-green, some of the feathers of back with small spots and bands of orange-buff ; upper-tail coverts and sides of rump broadly banded with buff-yellow ; lining of wing deep ochraceous-buff ; primaries ochraceous-rufous with dark olive-green spots on outer webs, greenish dusky bands on inner webs, and greenish dusky tips ; secondaries and tertials similar, but broadly edged on outer webs with yellowish olive-green like back, so that when the wing is closed the ochraceous-rufous color shows only along the inner edges of the wings ; tail greenish dusky with narrow olive-green edges, the outer rectrix spotted toward base of outer web and longitudinally marked toward end along both webs near quill with ochraceous-rufous ; throat dull olive-green narrowly banded on lower part with dull yellow ; lower neck and breast dull olive-green each feather with a yellowish tip and a large spot of yellowish running nearly across the middle ; belly, sides, and under-tail coverts, strong buff-yellow with a greenish tinge irregularly barred with narrow bands of dusky.

Measurements. — Adult ♂, type, wing, 108. ; tail, 62. ; tarsus, 16. ; exposed culmen, 18.5.

[1] *Trogon concinnus* Lawrence, Ann. Lyc. Nat. Hist. N. Y., 1862, Vol. VII., p. 463.

[2] Allophyeus, of another race.

Remarks. — True *Chloronerpes simplex* Salvin was originally described from Bugaba, and the type is a female; since 1870 its range has been traced northward through Costa Rica to La Libertad, Chontales, Nicaragua.[1] It is probably everywhere a rare bird; Mr. Brown never saw it during the time he was in Chiriqui, and the U. S. National Museum has but one or two specimens from Costa Rica. The form just described appears to be, so far as can be determined from a single specimen, a very well-marked northern race, much smaller and otherwise different. It must also be a very rare bird, as I do not find it listed in any of the published accounts of collections made in Honduras.

Melanerpes pucherani (Malh.).

Seven specimens, both sexes; Yaruca.

Melanerpes santacruzi pauper (Ridg.).

Twelve specimens, both sexes; Ceiba.

Sphyropicus varius (Linn.).

Two females; Ceiba.

Veniliornis caboti (Malh.).

One adult ♂; Yaruca.

Campophilus guatemalensis buxans Bangs.

One adult ♂; Yaruca.

Ceophloeus scapularis (Vig.).

Three specimens, both sexes; Ceiba and Yaruca.

Picumnus dimotus,[2] sp. nov.

Two specimens, adult ♂ & ♀; Ceiba.

Type. — From Ceiba, Honduras, sea level, adult ♂, No. 10,328, Coll. of E. A. and O. Bangs. Collected Jan. 21, 1902, by W. W. Brown, Jr.

Characters. — Nearest to the geographically remote *Picumnus olivaceus olivaceus* Lafr. of the Bogota region of Colombia; the male with the crown

[1] Salvin and Godman, Biol. Cent. Amer. Aves, Vol. II., p. 410. The type specimen is shown on Plate 59, Fig. 2.

[2] Dimotus, separated, removed.

spotted with scarlet as in that form; differs in being much more greenish, less brownish throughout; throat greenish white instead of fulvous; sides of breast and back much greener, less brown, striping of belly less well marked, the dusky stripes paler in color and much less distinct.

Color. — Adult ♂, type, pileum black with small, round white spots on occiput, and brilliant orange-scarlet tips to the feathers of crown and forehead, back dull olive-green without brownish tinge; wings dusky, the lesser coverts edged like back; secondaries and tertials edged with rather paler, more yellowish green; central upper-tail coverts yellowish; tail black, the inner webs of central rectrices yellowish white and the two outer pairs much marked with the same color; lining of wing dull greenish white; throat and malar region greenish white slightly marked with blackish; auriculars dusky brown; breast dull olive-green; belly, sides, and under-tail coverts, pale, dull olive-yellow striped with dull olive — the striping rather indistinct and irregular.

The adult ♀ differs from the ♂ only in having the whole pileum black with small, round white spots.

Measurements. — Adult ♂, type, wing, 52.; tail, 26.5; tarsus, 11.8; exposed culmen, 12.2. Adult ♀ topotype, No. 10,329; wing, 52.; tail, 27.; tarsus, 13.; exposed culmen, 11.4.

Remarks. — The new form ranges through Honduras and Nicaragua, though its exact limits are not at present known. It is, however, wholly isolated from the South American species it most nearly resembles, by *Picumnus olivaceus flavotinctus* Ridg., which occupies Panama, Chiriqui, and Costa Rica. In the large series I have examined (my specimens from Panama, Chiriqui, and Honduras and the considerable series in the U. S. National Museum) I find no sign of intergradation between *P. olivaceus flavotinctus* and *P. dimotus.*

Much confusion of the various races of this group of Picumnus has prevailed, until very recently, when Hartert (Novitates Zoologicæ, 1902, Vol IX., pp. 606 and 607) distinguished them in a masterly way. The northern form which I have just described appears, however, to have been wholly unknown to Hartert.

Todirostrum cinereum (Linn.).

Two males; Ceiba and Yaruca.

Myiopagis placens placens (Scl.).

One ♂; Ceiba.

Elainea flavogastra subpagana (Scl. and Salv.).[1]

Two specimens, ♂ and ♀; Ceiba.

[1] Lönnberg, Ibis, April, 1903, pp. 241–242.

Myiozetetes similis superciliosus (Bp.).

Twelve specimens, both sexes; Ceiba and Yaruca.

Pitangus derbianus (Kaup.).

Twenty-eight specimens, both sexes; Ceiba and Yaruca. This series represents a form slightly different from Mexican specimens upon which *P. derbianus* was founded. The Honduras birds average a little smaller, and brighter yellow below and darker, less rusty above. The differences, however, are slight, and only show when large series are compared. I suppose it is the *Sauraphagus guatimalensis* Lafr., a hardly well enough defined form to recognize by name.

Megarhynchus pitangus mexicanus (Lafr.).

Four specimens, both sexes; Ceiba and Yaruca.

Myiobius sulphureipygius (Scl.).

One ♂; Yaruca.

Empidonax traillii traillii (Aud.).

Two specimens, ♂ and ♀; Ceiba.

Empidonax flaviventris (Baird).

Two males; Yaruca.

Myiarchus crinitus (Linn.).

Two males; Ceiba.

Myiarchus mexicanus mexicanus (Kaup).

One adult ♂; Ceiba.

Myiarchus lawrencii lawrencii (Giraud).

Twenty-five specimens, both sexes; Ceiba and Yaruca.

Tyrannus melancholicus satrapa (Licht.).

Seven specimens; Ceiba. Some of these approach *T. m. couchi*.

Pipra mentalis mentalis (Scl.).

Eight specimens, both sexes; Ceiba. This series compared with the birds Mr. Brown collected in Chiriqui emphasizes the differences between the northern and southern races, the skins being of the same "make," and proves my *Pipra mentalis ignifera* to be a very well-marked form.

Manacus candei candei (Parzud).

Nine specimens, both sexes; Ceiba.

Scotothorus veraepacis veraepacis (Scl.).

One adult ♀; Yaruca.

Tityra semifasciata personata (Jard. and Selb.).

Five specimens, both sexes; Ceiba and Yaruca.

Tityra albitorques fraserii (Kaup).

One adult ♂; Yaruca.

Platypsaris aglaiae obscurus Ridg.

Five specimens, both sexes; Ceiba. I have compared these with the type of *P. obscurus*, and they appear to belong to this very dark form. The adult males in the present series are, however, rather blacker, less slaty above, and not quite so dark below.

Pachyrhamphus cinnamomeus (Lawr.).

One adult ♂; Yaruca.

Lipavgus holerythrus Scl. and Salv.

Two specimens, ♂ and ♀; Yaruca.

Attila citreopygius (Bp.).

One ♂; Ceiba.

Cotinga amabilis Gould.

Fifty-one specimens, adults of both sexes, and young males changing into the blue dress; Ceiba. All these were shot in one tree, the fruit of which they were feeding upon; and where, Mr. Brown tells me, he might have shot very many more.

Carpodectes nitidus Salv.

Five adult males; Ceiba. This record extends the range of the species from eastern Nicaragua to central, eastern Honduras. Mr. Brown took these five males from one dead tree, on different occasions. He tells me he never passed this tree without seeing one or more snow-white Cotingas sitting motionless in it. No females or young males were seen. Only once did he see the species elsewhere, and then but one adult male in the forest, that he was unable to get within shot of.

Thamnophilus transandeanus Scl. + Thamnophilus melanocrissus Scl.

One adult ♂; Ceiba. This specimen is intermediate between *T. transandeanus* and *T. melanocrissus.* The under-tail coverts are tipped with white, but not so broadly as in southern examples — true *T. transandeanus.*

Thamnophilus naevius (Gml.).

One male; Ceiba.

Thamnophilus doliatus (Linn.).

Eight specimens, both sexes; Ceiba. These specimens of course represent the so-called *T. intermedius* of Ridgway, but I cannot see how that bird differs from true *T. doliatus.* The size of the bill varies much, but perhaps the bills of the Central American birds average a trifle larger than in typical *T. doliatus* from Guiana; still individual specimens cannot be picked out by this or any other character. One of my Honduras skins — a fully adult ♂ — has actually a smaller bill than any specimen from Guiana with which I have compared it.

Automolus cervinigularis (Scl.).

Three specimens, both sexes, Yaruca.

Dendrornis nana confinis, subsp. nov.

Type (and only specimen) from Ceiba, Honduras, sea level, adult ♂ No. 10,432, Coll. of E. A. and O. Bangs, collected Jan. 24, 1902, by W. W. Brown, Jr.

Characters. — Similar to *D. nana nana* Lawr. of Panama and *D. nana costaricensis* (Ridg.), of Costa Rica and Chiriqui, but differing from either in having the throat much paler, nearly white; the shaft-stripes on breast paler, more whitish; the shaft-spots on pileum larger; and the shaft-stripes on nape and upper back much larger and more conspicuous.

Measurements. — Type, adult ♂, wing, 99.; tail, 86.5; tarsus, 22.5; exposed culmen, 34.

Remarks. — I have lately examined and studied with great care a large series (my specimens and all those in Washington) of *Dendrornis nana* and find the supposed great amount of variation in this species to be geographical and not individual. Any series of specimens from one place varies surprisingly little. Three very well-defined subspecies can easily be made out, as follows: —

Dendrornis nana nana Lawr.

Type locality; Panama.

Throat and shaft-stripes on breast dull ochraceous-buff; ground color of breast, belly, and sides dull raw umber.

Dendrornis nana costaricensis (Ridg.).

Type locality; Tucurrique, Costa Rica (extending southward into Chiriqui and northward into Nicaragua).

Throat and shaft-stripes on breast, buff yellow; ground color of breast, belly, and sides dull tawny olive.

Dendrornis nana confinis Bangs.

Type locality; Ceiba, coast of Honduras.

Throat, cream buff; shaft-stripes on breast buff; ground color of breast, belly, and sides, pale raw-umber; shaft-spots of pileum and shaft-stripes on nape and upper back much larger and more conspicuous than in either of the preceding.

Dendrornis erythropygia Scl.

One adult ♀; Yaruca.

Picolaptes compressus (Cab.).

Seven specimens, both sexes; Ceiba and Yaruca. Honduras examples seem best referred to true *P. compressus*, though they show an approach to *P. compressus insignis* Nels. of southeastern Mexico, both in the markings of the back and in measurements. *P. compressus insignis* has a larger bill as well as a longer tail than true *P. compressus.*

Dendrocolaptes sanctithomae (Lafr.).

One adult ♀; Yaruca.

Galeoscoptes carolinensis (Linn.).

Eight specimens, both sexes; Ceiba and Yaruca.

Merula grayii grayii (Bp.).

Twelve specimens, both sexes ; Ceiba and Yaruca.

Hylocichla mustelina (Gml.).

Seven specimens, both sexes ; Ceiba and Yaruca.

Thryothorus maculipectus umbrinus Ridg.

Eight specimens, both sexes ; Ceiba and Yaruca.

Henicorhina prostheleuca Scl.

Two specimens, ♂ & ♀ ; Yaruca.

Tachycineta albilinea (Lawr.).

Three specimens, both sexes ; Ceiba and Yaruca.

Setophaga ruticilla (Linn.).

Three males ; Ceiba.

Wilsonia mitrata (Gml.).

Five specimens, both sexes ; Ceiba and Yaruca.

Icteria virens virens (Linn.).

Six specimens, both sexes ; Ceiba and Yaruca.

Geothlypis trichas brachidactyla (Swains.).

One adult ♂ ; Ceiba.

Seiurus motacilla (Vieill.).

One ♂ ; Yaruca.

Seiurus noveboracensis notabilis Ridg.

Two males; Ceiba and Yaruca. Both specimens are placed with this subspecies, the one from Ceiba being typical, the other is a little smaller and more yellowish below and may have been bred in an intermediate region, but it is rather nearer to *notabilis* than to true *noveboracensis*.

Dendroica coronata (Linn.).

Three males; Ceiba, none of them in full plumage.

Dendroica maculosa (Gml.).

Three specimens, both sexes; Ceiba and Yaruca.

Chrysocantor[1] aestiva aestiva (Gml.).

Three males; Ceiba.

Mniotilta varia (Linn.).

Two males; Ceiba.

Cyanerpes cyaneus (Linn.).

Seven specimens, females and young males, but no adult males; Ceiba. Ridgway in Bulletin of the United States National Museum No. 50, Part II., does not recognize the Central American subspecies *carneipes*, and I have followed him in calling these true *cyaneus*.

Cyanerpes lucida (Scl. and Salv.).

Twenty specimens, both sexes; Ceiba.

Chlorophanes spiza guatemalensis (Scl.).

Seven specimens, both sexes; Ceiba.

Icterus prosthemelas (Strick.).

Thirty-two specimens, both sexes; Ceiba and Yaruca.

[1] I use the generic name proposed for the Golden wood warblers by C. J. Maynard (The Warblers of New England, Part III., 1901, p. 58), because these compose a well-defined group, quite as well entitled to generic rank as other "genera" long recognized in the family.

Icterus spurius (Linn.).

Six specimens, both sexes; Ceiba.

Icterus galbula (Linn.).

Eleven specimens, both sexes; Ceiba.

Gymnostinops montezuma (Less.).

Three specimens, both sexes; Ceiba.

Phoenicothraupis rubica rubicoides (Lafr.).

Six specimens, both sexes; Yaruca.

Phoenicothraupis salvini salvini Berl.

Eighteen specimens, both sexes; Ceiba and Yaruca.

Eucometis spodocephala spodocephala (Bp.).

Four specimens, both sexes; Ceiba.

Lanio aurantius Lafr.

One adult ♀; Yaruca.

Ramphocelus passerinii Bp.

Thirty-nine specimens, both sexes; Ceiba and Yaruca.

Phlogothraupis sanguinolenta (Less.).

Eight specimens, both sexes; Ceiba and Yaruca.

Piranga rubra rubra (Linn.).

Nineteen specimens, both sexes; Ceiba and Yaruca.

Piranga leucoptera leucoptera Trudeau.

One adult ♂; Yaruca.

Tanagra cana Swains.

Fourteen specimens, both sexes; Ceiba.

Tanagra abbas Licht.

Eighteen specimens, both sexes; Ceiba and Yaruca.

Calospiza lavinia (Cass.).

Two specimens, ♂ and ♀; Ceiba. This is the most northern record for the species, previously traced only to southern Nicaragua, — Chontales. The present specimens are not typical, and I have no doubt that they represent a well-defined northern race. In color they do not differ from southern specimens, but they are much larger, and have very long, slender bills. I prefer, however, not to name a subspecies on mere differences of size and proportions without a much greater amount of material. The two skins measure as follows: No. 10,024, ♂, Ceiba, Honduras, Jan. 9, 1902; wing, 73.; tail, 50.5; tarsus, 19.; exposed culmen, 12.4; no. 10,025, ♀, Ceiba, Honduras, Jan. 20, 1902; wing, 70.; tail, 48.; tarsus, 17.2; exposed culmen, 12.

Calospiza larvata larvata (Du Bus.).

Eighteen specimens, both sexes; Ceiba and Yaruca.

Euphonia hirundinacea Bp.

One adult ♂; Ceiba.

Euphonia gouldi Scl.

Six adults, both sexes; Ceiba.

Chlorophonia occipitalis (Du Bus.).

Two specimens, ♂ & ♀; Ceiba. Previous to Mr. Brown's taking this pair, *Chlorophonia occipitalis* was known only from southeastern Mexico and the highlands of Guatemala. The Guatemalan bird has been named by Dubois, *C. cyaneidorsalis*, but has since been generally refuted. My two Honduras specimens differ from any others I have seen in the very small area occupied by the blue crown patch, and may eventually prove distinct.

Saltator atriceps atriceps Less.

One adult ♂; Yaruca.

Saltator magnoides medianus Ridg.

Twelve specimens, both sexes; Yaruca.

Saltator grandis (Licht.)

Two adult males; Ceiba.

Zamelodia ludoviciana (Linn.).

Two males; Ceiba.

Guiraca caerulea caerulea (Linn.).

Three specimens, both sexes; Ceiba and Yaruca.

Oryzoborus funereus Scl.

One ♀; Ceiba.

Cyanospiza cyanea (Linn.).

One ♀; Yaruca.

Cyanospiza ciris (Linn.).

Five adult males; Ceiba. These birds, taken in January, are paler red below and have darker, more dusky blue heads, than breeding specimens from the southern United States.

Sporophila corvina (Scl.).

Five adult males; Ceiba and Yaruca.

Sporophila morelleti (Bp.).

Three specimens, both sexes; Ceiba.

Arremon aurantiirostris Lafr.

Two adult males; Yaruca.

Arremonops conirostris centratus, subsp. nov.

Three specimens, one ♂ and two females; Ceiba, January, 1902.

Type. — From Ceiba, Honduras, sea level, adult ♀, No. 10,141, Coll. of E. A. and O. Bangs, collected Jan. 24, 1902, by W. W. Brown, Jr.

Characters. — Nearest to *Arremonops conirostris richmondi* Ridg. but slightly smaller, especially the bill; darker in color throughout; breast and sides darker and purer gray; flanks less suffused with olive-green or brownish; tail and wings much darker green, wholly lacking the reddish or brownish olive of those parts in *A. conirostris richmondi*; back much darker — true olive-green; bend of wing and lining of wing paler yellow. From *Arremonops chloronotus* (Salv.) the new form differs in larger size, and in the crown stripes being wholly black unmixed with brown.

Measurements: —

No.	Sex.	Wing.	Tail.	Tarsus.	Exposed Culmen.
10,141 Type	♀ ad.	72.	67.	27.	15.0
10,139 Topotype	♀ ad.	72.	57.5	28.	16.2
10,140 do.	♂ ad.	70.5	63.	27.5	15.8

Remarks. — *Arremonops conirostris centratus* is intermediate between *A. conirostris richmondi* and *A. chloronotus*, but different enough from either to deserve a name. In the birds of North and Middle America, Ridgway[1] records *A. conirostris richmondi* from southern Honduras (Segovia River), and *A. chloronotus* from northern Honduras (San Pedro Sula), but specimens of the genus were not available from between these two regions, the area occupied by the new form.

MAMMALS.

Didelphis yucatanensis Allen.

One young adult ♀; Yaruca, 1,000 feet, Feb. 13, 1902. This specimen differs somewhat from true *D. yucatanensis*, and more material might prove the Honduras animal to be separable. The large opossums, on the other hand, are so variable that the peculiarities of this example may be only individual. The skull and teeth are slightly larger than in true *D. yucatanensis*, and the rostrum more swollen; the under fur also is buffy, or ochraceous to, in places yellowish.

Dr. Merriam has very kindly compared the specimen for me with the original series of *D. yucatanensis*, where he was unable to match it exactly. The flesh measurements taken by the collector are as follows: total length, 590; tail vert., 320; hind foot, with claw, 60; ear from notch, 45.

Cyclopes dorsalis (Gray).

One ♀; Ceiba, January 22.

[1] Bull. U. S. Nat. Mus., 1901, No. 50, Part I., pp. 452 and 454.

Sciurus (Echinosciurus) boothiae Gray.

Seven specimens; Ceiba and Yaruca.

This series is intermediate between true *S. boothiae* and *S. boothiae belti* Nelson, two skins being typical of the former and two of the latter, with the other three variously intermediate.

Sciurus (Baiosciurus) deppei Peters.

Twenty-four specimens; Ceiba and Yaruca. Among these skins there is a wide range of individual variation in color, — from pure white to yellowish rusty, below; above, the tone differs considerably in different individuals.

Nyctomys decolorus (True).

Eleven specimens, three of which are young; Yaruca, 1,000 feet. The type locality of this species is Rio de las Piedras, northern Honduras. In cranial characters the present series agrees very well with the type. In color, a comparison can hardly be made, the type being in poor condition. The present form is quite distinct from *N. nitellinus*, lately described by me [1] from Chiriqui, though possibly the two intergrade and are only subspecies. Comparing the Chiriqui series with the present one, the following differences are evident: the skull of *N. decolorus* is lighter and relatively wider posteriorly than that of *N. nitellinus; N. decolorus* has narrower and lighter nasals that end behind in a rounding point (the nasals of *N. nitellinus* are square posteriorly). In color the two forms are nearer than I had supposed by an examination of the type alone; they differ chiefly in *N. nitellinus* having a much more conspicuous and larger black whisker patch and broader black orbital ring.

Sigmodon hispidus borucae (Allen).

Twenty-two specimens, all from Yaruca, 1,000 feet.

In important characters these specimens do not differ from more southern examples of *S. hispidus borucae*, from Costa Rica and Chiriqui, but in color they average a little paler; individuals can be selected, however, from the two series that correspond exactly.

Sigmodon hispidus furvus, subsp. nov.

Type (and only specimen) from Ceiba; Honduras, sea level, adult ♂, No. 10,665, Coll. Mus. Comp. Zoöl., collected Jan. 16, 1902, by W. W. Brown, Jr.

Characters. — Nearest to *Sigmodon hispidus saturatus* Bailey of Teapa, Tabasco, Mexico, but darker in color; less rusty above; tail blacker, and under

[1] Bull. M. C. Z., 1902, Vol. XXXIX., p. 30.

parts redder; skull similar, except audital bullae wider and flatter and basioccipital longer and narrower.

Color. — Upper parts, dark rich brown, between mummy brown and burnt umber, rather redder on rump, the head, back, and rump darkened and varied by a copious sprinkling of brownish black tipped hairs; under parts strong, buffy ochraceous; feet and hands dark brown, the hairs colored about like those of the back; ears blackish, nearly naked externally, sparsely haired inside, the color of these hairs about like those of the back; tail black, nearly unicolor, being only just perceptibly paler below.

The specimen is in long, fresh, unworn pelage, and there are a few pure white hairs scattered at irregular intervals along the back and sides.

Measurements. — Adult ♂, type, total length, 265; tail vert., 105 (the tip of the tail is gone, probably 5 to 10 mm.); hind foot, with claw, 32; ear, from notch, 18. Skull, basal length, 31.4; occipitonasal length, 35.8; zygomatic width, 20.4; mastoid width, 15.2; interorbital width, 5; length of nasals, 12.6; length of palate to palatal notch, 16.2; length of upper molar series, 6.; length of single half of mandible, 20.

Remarks. — Mr. Vernon Bailey kindly compared the two forms of *Sigmodon* contained in the present collection for me, with the Mexican series in the collection of the Biological Survey, and we agree that the one from the coast is a new form most closely related to *S. hispidus saturatus*; and that the form from farther inland is not separable from *S. hispidus borucae*, which thus has a wide range for a member of this group.

Oryzomys couesi (Alston).

Thirty-six specimens; Yaruca, 1,000 feet.

Oryzomys rhabdops Merriam.

Nineteen specimens; Yaruca. Among the skulls of this series there is a tendency to a peculiar swelling between the orbits; several specimens, however, do not show this at all, and apart from this tendency the specimens from Honduras are exactly like the type series from Calel, Guatemala.

Heteromys griseus Merriam.

Two specimens, ♂ & ♀; Yaruca. Dr. Merriam has compared these with his extensive Mexican material, and they prove to be identical with *H. griseus* from the mountains near Touala, Chiapas, Mexico.

Dasyprocta punctata Gray.

Two adult females; Yaruca.

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AT HARVARD COLLEGE.

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CARBONIFEROUS FISHES FROM THE CENTRAL WESTERN STATES.

By C. R. Eastman.

With Five Plates.

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No. 7. — *Carboniferous Fishes from the Central Western States.*

By C. R. Eastman.

The present contribution embodies the results of investigations of an extended series of Carboniferous fishes from the Mississippi and Missouri Valley region, and is essentially a continuation of "Some Carboniferous Cestraciont and Acanthodian Sharks."[1] With regard to faunal relations, the subject-matter of the following pages falls naturally into a threefold division. Attention is first claimed by the Upper Carboniferous fish-fauna of Kansas and Nebraska, which is one of great interest palaeontologically and morphologically. The Coal Measure fish-fauna of Mazon Creek, Illinois, is considered next, and the structure of several new and little-known forms illustrated. Last in order of discussion are certain new or little-known species from the Mississippian series, which appear worthy of notice either on account of their morphologic interest, or because of their relations to other well-known forms. The greater part of the material upon which the following observations are based is preserved in the Museum of Comparative Zoölogy at Cambridge, and so far as possible the location of types and figured specimens is given under the caption of the several species, in the case of all those belonging to other institutions.

I. THE UPPER CARBONIFEROUS FISH-FAUNA OF KANSAS AND NEBRASKA.

Altogether, about fifteen species of Upper Carboniferous fishes have been described from Kansas and Nebraska in the writings of J. Leidy,[2] O. H. St. John,[3] St. John and Worthen,[4] and S. W. Williston.[5] To

[1] Bull. Mus. Comp. Zoöl., Vol. XXXIX., 1902, No. 3.

[2] Extinct Vert. Fauna Western Territ. Rept. U. S. Geol. Surv. Territ., Vol. I., 1873, pp. 311–313.

[3] Hayden's Final Rept. U. S. Geol. Surv. Nebraska, 1872, pp. 239–245.

[4] Palaeontology of Illinois, Vol. VI., 1875; *ibid.*, Vol. VII., 1883.

[5] Kansas Univ. Quart., Vol. VIII., 1899, p. 178.

these must be added also a single tooth of a Cladodont shark from the Permo-Carboniferous of Blue Springs, Nebraska, which is made by Cope[1] the type of his so-called ***Styptobasis knightiana.*** The Missourian fish-fauna of Kansas and Nebraska consists almost exclusively of Elasmobranchs, and is directly successional to the Lower Coal Measure and Mississippian assemblages occurring throughout a wide area to the eastward of these States, its relations with the Chester fauna of Kentucky, Illinois, and Missouri being not its least striking feature.

During the last few years a considerable quantity of new material has been brought to light, chiefly through the activity of Prof. Edwin H. Barbour, Director of the Nebraska University Geological Survey, and his sister, Miss Carrie A. Barbour, of the State University at Lincoln. The writer owes it to the kindness of Dr. and Miss Barbour that all of the specimens collected by them have passed through his hands, and that a number of them are illustrated in the present paper. Acknowledgments are also due to Dr. S. W. Williston of Chicago University, and to Prof. W. C. Knight of Wyoming State University, for the generous loan of material under their charge. Having these facilities at one's command, it seems desirable to present a synopsis of the trans-Missourian fish-fauna which shall be as complete as the present state of our knowledge permits, and this is the endeavor of the following pages.

The stratigraphy and palaeontology of the eastern parts of Kansas and Nebraska have been studied in great detail by a number of geologists during the last few years with special reference to the question of the homotaxial relations of the so-called Permian beds. The discovery of supposed Permian fossils from this region was first reported by Swallow in 1858, and in the spirited controversy which followed, Meek, Swallow, Hawn, Shumard, Hayden, Newberry, Marcou, Geinitz, and others participated, arguing either for or against the recognition of the Permian as a distinct epoch in North American geology. Later the subject was discussed by White and Broadhead to some extent, and more recently Prosser, Cragin, Cummins, Keyes, Tarr, Haworth, Knight, Darton, and Frech have made important contributions to the literature of the Permian question.

It seems to have been established that there are from 1000 to 1350 feet of fossiliferous sediments overlying the Upper Coal Measures (Missourian series) of the Kansas-Nebraskan area, in which faunas succeed one another uninterruptedly from base to summit, as was first contended by Meek. The lower 400 feet (Neosho and Chase formations) con-

[1] Proc. U. S Nat. Mus., Vol. XIV., 1891, p. 447.

stitute a distinct terrane, — often referred to as the Permo-Carboniferous, — the majority of its species being common to the Upper Coal Measures, and perhaps one-half of the species occurring in the succeeding 300 or 400 feet (Sumner stage of Cragin) being also common to them. But in the upper terrane, the so-called "Red Beds" or Cimarron series, which exhibit a thickness further southward of from 1000 to perhaps 2200 feet, no fossils have been found which are at all closely related to those of the Coal Measures, and writers are pretty generally agreed in correlating this series with the Upper Permian (Neo-Dyas) of Europe.

In the same way there appears to be good reason for believing that the lower part of the Big Blue series (Chase and Neosho strata) correspond to the Artinsk stage, which is the oldest Permian of Russia. Owing to the absence of Cephalopods, however, and general transitional character of the Neosho, no distinct line of separation between the Lower Permian and Carboniferous can be said to exist. The demarcation between the two systems is drawn by Frech[1] at the base of the Chase stage, and this limit for the Lower Permian is also accepted by Prosser,[2] who places the Neosho member at the summit of the Missourian. In Prosser's original description of these formations, however, the line of separation between the Upper Coal Measures and Permian was doubtfully drawn between the Cottonwood and Neosho formations, an arrangement in which a number of writers have concurred.

Regarding the transitional faunal characters, it is remarked by Keyes[3] that "the most noteworthy feature of the organic remains, viewed as a whole, is the gradual replacement of a purely marine type by a shore and brackish water phase, as the change from open sea to closed water conditions took place, and finally to those in which life could not exist. . . . In this region as in Russia, the gradual replacement of a brachiopodous fauna by a Permian lamellibranch fauna follows the local change of open to closed sea conditions. The Permian element of these forms was merely a shallow water facies of the more typical Carboniferous fauna."

In Nebraska the so-called Permo-Carboniferous (Chase and Neosho) strata form the northern continuation of the Kansas beds, and agree with them in all essential characters. The area is described by Knight[4]

[1] Lethaea Palaeozoica, Vol. II., 1899, p. 378.

[2] Revised Classification of the Upper Palaeozoic Formations of Kansas. Journ. Geol., Vol. X., 1902, p. 711.

[3] Journ. Geol., Vol. VII., 1899, p. 354, *et seq.*

[4] *Ibid.*, p. 360.

as "of flat-iron shape, with the broad end to the south resting upon the Kansas-Nebraska line. The northern limit is probably in the vicinity of Roca, Lancaster County. On the east the boundary has only been approximated, . . . but it is supposed that it extends from Roca south and east into Johnston County, thence southward through the western end of Pawnee County into Kansas. The western boundary, from Roca to Beatrice, is also buried beneath a very thick bed of loess, but from Beatrice southward it is traced with considerable accuracy." An understanding of the stratigraphic relations of the Upper Palaeozoic rocks in

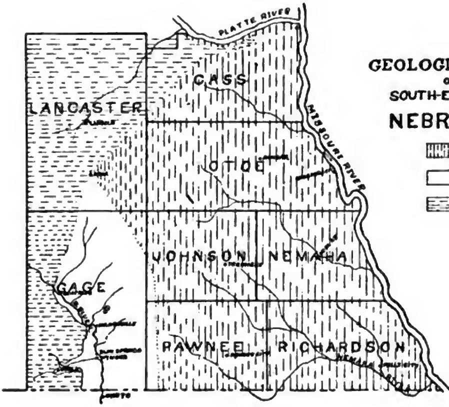


Fig. 1.

A Geological Map of Southeastern Nebraska (after Knight).

Nebraska will be facilitated by an inspection of the accompanying sketch-map and section, taken from Professor Knight's article, and of the following table of formations. The stratigraphy of the Kansas Coal Measures is described in the report of the University Geological Survey of Kansas, particularly in Volume III. by E. Haworth.

Nearly all of the fish-remains described in the present paper are from the Atchison shales, the principal localities being in Cass, Gage, Lancaster, Nemaha, and Sarpy counties. According to Dr. Barbour, the exposures at Cedar Creek, Louisville, South Bend, and Table Rock may be referred to the summit of the Atchison, and those at Richfield and Springfield to its base. At Manhattan, Kansas, both the Atchison and Cottonwood are exposed.

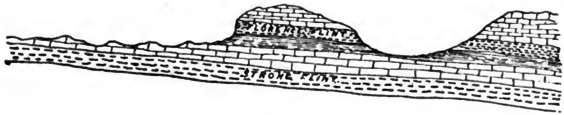


FIG. 2.

A Geological Section of the Nebraska Permo-Carboniferous south and east from Beatrice to the Kansas line (after Knight).

SECTION OF THE UPPER PALAEOZOIC IN KANSAS AND NEBRASKA.

Permian System	Cimarron series	Kiger shales	
		Salt Fork shales	
	Big Blue series ("Permo-Carboniferous")	Wellington shales	
		Marion limestone	
		Chase limestone	Florence flint
		Neosho shales	Strong flint
Carboniferous System (Upper part only)	Missourian series	Cottonwood limestone	
		Atchison shales	
		Forbes limestone	
		Platte shales	
		Plattsmouth limestone	
		Lawrence shales	

With these general remarks, we may now pass on to a consideration of the fish-fauna of the Kansas-Nebraska area in systematic order.

ELASMOBRANCHII.

PLEURACANTHIDAE.

Pleuracanthus (Diplodus) compressus NEWBERRY.

1856. *Diplodus compressus* J. S. Newberry, Proc. Acad. Nat. Sci. Philad., p. 99.
1866. *Diplodus compressus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 60, Pl. IV., Fig. 2.
1870. *Diplodus compressus* O. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 432.

1872. *Diplodus compressus* O. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 240, Pl. IV., Fig. 19.

1873. *Diplodus compressus* J. S. Newberry, Rept. Geol. Surv. Ohio, Vol. I., Pt. ii., p. 335.

1875. *Diplodus compressus* J. S. Newberry, *Op. cit.*, Vol. II., Pt. II., p. 45, Pl. LVIII., Fig. 2.

A single tooth of this species, from the Missourian of Rulo, Nebraska, is described and figured by St. John (1872), but no other examples have since been reported from this region. The species also occurs in the Upper Coal Measures of south-western Iowa, Indiana, and Ohio. Teeth of *D. platypternus* Cope are abundant in the Permian "Red Beds" of Texas.

CLADODONTIDAE.

Cladodus occidentalis Leidy.

(Plate 2, Figs. 3, 8, 9.)

1859. *Cladodus occidentalis* J. Leidy, Proc. Acad. Nat. Sci. Philad., p. 3.

1866. *Cladodus mortifer* Newberry and Worthen, Pal. Illinois, Vol. II., p. 22, Pl. I., Fig. 5.

1870. *Cladodus mortifer* O. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 431.

1872. *Cladodus mortifer* O. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 239, Pl. III., Fig. 6, Pl. VI., Fig. 13.

1873. *Cladodus occidentalis* J. Leidy, Rept. U. S. Geol. Surv. Territ., Vol. I., p. 311, Pl. XVII., Figs. 4–6.

1897. *Cladodus mortifer* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 285, Pl. XXII., Fig. 2.

The best description of this species is that given by St. John in 1872, who reports its occurrence in the Missourian of the Nebraska City section, Manhattan, Kansas, and south-western Iowa. Teeth of this species occur also in the Coal Measures of Illinois and Indiana.

A number of fragmentary teeth have been obtained by Professor Barbour from the Permo-Carboniferous of Roca, and Atchison shales (Missourian) of Table Rock, Nebraska, three of which are shown in the accompanying illustrations.

Cladodus knightianus (Cope).

(Plate 2, Fig. 4.)

1891. *Styptobasis knightiana* E. D. Cope, Proc. U. S. Nat. Mus., Vol. XIV., p. 447, Pl. XXVIII., Fig. 2.

Type. — Imperfect crown; Museum of the State University of Nebraska.

The solitary example upon which Cope based his definition of this species was obtained by W. C. Knight from the "Florence Flint" (Chase formation) of Blue Springs, Nebraska, and is shown of the natural size in Plate **2**, Fig. 4. Inspection shows that Cope mistook the worn base of the crown for a truncate root, in allusion to which the name Styptobasis was given; and so far as may be judged from the form and ornamentation of the crown, it differs from the foregoing species merely in the fact of being somewhat more robust. The shallow median depression at the base of the crown on its outer face likewise occurs in *C. occidentalis*. Another Cladodont tooth, scarcely distinct from the latter species, is described by O. P. Hay under the name of *C. girtyi*, from the Coal Measures of Colorado.

Formation and Locality. — Permo-Carboniferous; Blue Springs, Nebraska.

Phoebodus knightianus, sp. nov.

(Plate 4, Figs. 40, 40 *a*.)

Type. — Imperfect tooth; Museum of Comparative Zoölogy.

From the same locality as the preceding, Professor Knight secured some years ago one nearly perfect tooth and the root of a second specimen, which he cited as "*Diplodus*, sp. nov." in his faunal list of the Kansas and Nebraska Permo-Carboniferous.[1] Through the courtesy of their discoverer, these specimens have come into the possession of the Museum of Comparative Zoölogy, and form the basis of the following description. It is stated in a letter from Professor Knight that his attempt to remove some of the adherent matrix from the more perfect tooth resulted in some injury to the latter, and the broken parts were unfortunately not preserved. He had, however, observed that the three principal cones were all of the same height, and that the base was symmetrically developed. Accordingly, in the figures here given of the fractured specimen, its original outline is restored on Professor Knight's authority.

Teeth of moderate size, the median and two outer cones of equal height, and no intermediate denticles. All three cusps stout and erect, convex on both faces, with sharp lateral carinae, and a few delicate, slightly curved striae extending for a short distance upward from the base. Attached surface of root nearly plane, with a single pad-like prominence directly underneath the median cone; postero-superior surface with a rounded "button."

The root agrees in size and general form with that of *Diplodus platypternus* Cope, except that both the posterior button and antero-inferior prominence are of relatively smaller size. From *Phoebodus politus* Newb. and other Devonian species the present form is distinguished by the absence of intermediate denticles, a character in which it agrees with the Triassic *P. brodiei*. The type specimen is shown of four times the natural size in Plate **4**, Figures 40 and 40 *a*, but in these illustrations the anterior boss on the lower surface of the root

[1] Journ. Geol., Vol. VII., 1899, pp. 366, 372, 374, 491.

is represented a little too conspicuously. In Figure 39 of the same plate is shown a tooth belonging to another species of Phoebodus. A good figure of *P. politus* Newb., from the Cleveland Shale of Ohio, may be found in the Journal of Geology, Vol. VII., 1899, p. 492.

Formation and Locality. — Permo-Carboniferous; Blue Springs, Nebraska.

PETALODONTIDAE.

Fortunate discoveries of Janassa afford the means for a clear understanding of the dentition and form of body in the ray-like creatures belonging to this family. Janassa exhibits a ray-shaped trunk covered with smooth, rounded, quadrate granules, and large pectoral fins which extend forward to the head, the pelvic pair being separated from them by an interspace. There are no fin-spines, the mouth-cleft is very narrow, as in rays, and the tail is slender. There can be no doubt that forms like this, or like Tamiobatis, Copodus, Psammodus, Archaeobatis, etc., were early approximations to the modern ray type, whether we consider them as genetically related to the latter or not.

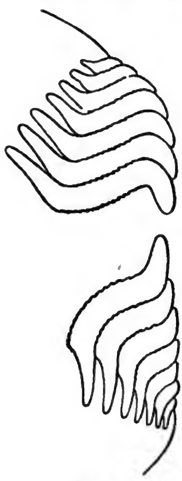


Fig. 3.

Diagram showing arrangement of upper and lower dentition in *Janassa bituminosa* Schloth. (Slightly modified after the restorations by Hancock and Howse, and O. Jaekel.) × ⅔.

The dentition of Janassa, as determined with entire accuracy by Hancock and Howse in *J. bituminosa*, is similar in both jaws, and consists of a median or symphysial, and three pairs of lateral series, each having from four to seven teeth, the lateral series diminishing regularly in size from the center outwards. The lower dentition is more strongly arched and at the same time less extended from side to side than the upper, and the cutting-margins of the lower functional teeth bite inside those of the opposite jaw. The teeth of the outermost lateral series in the upper jaw slightly exceed those of the corresponding lower rows in width. The manner of succession is peculiar in that the oldest-formed teeth, after they have ceased to be functional, become piled upon one another in front of and away from the oral margin, thus affording firm support for the functional ones (*cf.* Text-fig. 3). The teeth of each series are closely wedged together and interlock with those of adjoining rows, the whole forming a very compact mass.

The arrangement of teeth in Janassa is well illustrated in the figures given by Hancock and Howse over thirty years ago,[1] and more recently by Jaekel,[2] the latter author reaffirming the correctness of his predecessors' conclusions. According to these writers, the strongly reflected, scoop-like extremity of the crown served for a cutting-margin, and the pavement-like, rugose, or imbricated portion as a triturating surface. This interpretation appears plausible enough in the case of some species, but must not be supposed to be of universal application amongst Petalodonts, very different conditions having existed in certain other genera. Teeth of Petalodus and Petalorhynchus have been found in successional series, the crowns overlapping and more or less erect (*cf.* Text-fig. 4), but it is not known how many of such series constituted the complete dentition. In these genera, as in Janassa, the median series are larger than the rest and bilaterally symmetrical, those of the lateral series more or less oblique. It was long ago observed by Hancock and Howse[3] that Petalodus was provided with both symmetrical and oblique rows of teeth, and that examples had been "found lying in regular order, as if forming a portion of a vertical row." Consequently we must express ourselves as at variance with Jaekel's conjecture that the teeth of Petalorhynchus probably represent the symphysial series of Petalodus, their disparity in size and discordant distribution clearly entitling them to recognition as distinct genera. There are also excellent reasons for dissenting from his proposed union of Petalodus and Ctenoptychius, and from his theoretical association of the fin-spines known as Stichacanthus and Physonemus (including Xystracanthus and Batacanthus), with Polyrhizodus and Petalodus respectively. Not only do the facts of distribution militate with this last assumption, but the absence of fin-spines in Janassa renders it extremely improbable that such defences were present in other members of the same family.

FIG. 4.

Petalorhynchus psittacinus (M'Coy). Lower Carboniferous; Armagh, Ireland. Naturally associated series of seven teeth. Outer face, × ½.

It is inferred by Hancock and Howse from the fineness of the cutting-edge in two species of Janassa that the food must have consisted of soft material. They state of *J. bituminosa* that "the scoop-like cutting-margin is certainly much used, for it is almost always greatly worn in a regular manner; only in one instance have we seen it a little broken. It would be an efficient instrument in cutting vegetable substances, and these might afterwards require the aid of the crushing-disk." The presence of a carbonaceous mass in the abdominal region of certain specimens also suggests to them herbivorous habits. Jaekel, on the other hand, in discussing the probable food of the Permian *J. bituminosa*,

[1] *Hancock, A.*, and *Howse, R.*, On Janassa bituminosa, Schlotheim. Ann. Mag. Nat. Hist. (4), Vol. V., 1870, p. 47, Pl. II., III.

[2] *Jaekel, O.*, Ueber die Organisation der Petalodonten. Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 258.

[3] *Loc. cit.*, p. 61.

argues from the worn condition of the triturating surface that the fare consisted of hard-shelled prey, such as Brachiopods and Pelecypods, and cites an example preserved in the Bergakademie in Berlin where a number of Productae are contained within the abdominal cavity. It is reasonable to suppose that the relative tenuity or thickness of the cutting-edge amongst different species of Janassa furnishes an approximate indication of their having subsisted on soft or hard shelled prey, as the case may be.

Janassa maxima, sp. nov.

(Plate 2, Fig. 21 ; Plate 3, Fig. 24.)

Type. — Imperfect crown ; University of Nebraska.

Teeth extremely large and robust, with very high and strongly reflexed crown and thick cutting-margin. Posterior two-thirds of oral surface convex and covered with numerous prominent oblique plicae displaying indications of wear during life. Anterior face strongly convex, smooth, the posterior two-thirds elevated into two abrupt longitudinal ridges which are separated by a broad median longitudinal channel. Anterior face showing marks of contact with next oldest underlying tooth, the only indications of wear during life being directly along the cutting-margin.

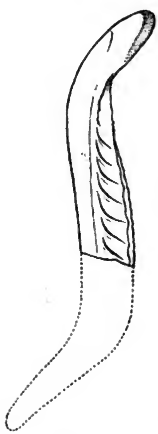


FIG. 5.

Janassa maxima, sp. nov. Profile, × ½.

Of this species only the unique tooth shown of the natural size in the accompanying illustrations is known at present. This is at least twice the size of the Permian *J. bituminosa* (Schloth.), the largest previously known species, which it approaches more closely than any others. In fact, the relations of this new species are altogether with those of Permian, rather than with those of Carboniferous age.

The whole of the root and posterior portion of the crown are missing, and a portion of the cutting-edge of the crown has also been broken away. Even in its mutilated condition, however, the crown exhibits a total length of nearly 5 cm. Its lateral borders are straight, proving that the tooth was not deformed by interlocking with those of adjoining series. As to the position in the mouth occupied by this tooth, the marks of wear indicate very clearly that it belonged in one of the principal series to the left of the symphysial in the upper jaw. The tooth opposed to it in the lower jaw played inside its cutting-edge, and slightly to the left instead of squarely against it. The asymmetrically worn condition of the cutting-edge in

J. bituminosa is very distinctly shown in Hancock and Howse's figures,[1] and also in Jaekel's.[2] There can be little doubt that the action of the jaws upon one another was similar to that obtaining in modern Gymnodonts and Chimaeras. It has been stated in the definition of this species that the anterior face of the crown exhibits marks of contact with the next older tooth which it displaced. These markings are of two kinds. In the first place a raised line extending parallel with the cutting-edge at a distance of about a centimeter behind it (Pl. **3**, Fig. 24) demarcates the area overlapped by the preceding tooth; in other words, it divides the exposed cutting-edge from the covered portion. Secondly, the longitudinal ridges on the anterior face display a number of parallel facettes caused by the impress of the oblique folds on the triturating surface of the next older tooth which this one displaced. Similar markings have been observed on the anterior face of teeth belonging to *J. bituminosa*, and this interpretation is given of them by Messrs. Hancock and Howse.[3] The thickness of the cutting-margin (*cf.* Text-fig. 5) and generally stout condition of the present specimen render it probable that the creature subsisted on hard-shelled prey.

Formation and Locality. — Atchison shales (Missourian); Richfield, Nebraska.

Janassa unguicula, sp. nov.

(Plate **2**, Fig. 13.)

Type. — Imperfect tooth; University of Nebraska.

Teeth delicate and of moderate size; crown much reflexed, regularly arched from side to side, and with a knife-edge trenchant margin. Outer coronal face smooth, posterior face entirely covered with fine longitudinal striae. Form of triturating surface and root unknown.

FIG. 6.

Janassa unguicula, sp. nov. Outer face of crown, × ½. *A*, Vertical section. *B*, Oral aspect, viewed from above, × ½.

This species is represented by a unique specimen from the Missourian of Cedar Creek, Nebraska, shown of the natural size in Plate **2**, Fig. 13, and Text-fig. 6. Only the cutting portion of the crown is preserved, the crushing surface (if one was indeed present) and root having been broken away. The size

[1] Ann. Mag. Nat. Hist. (4), Vol. V., 1870, Pl. II., Fig. 2.

[2] Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, Pl. XIV., Fig. 2.

[3] *Loc. cit.*, p. 55.

is approximately that of *J. clavata* from the British Carboniferous Limestone, the width being 1.4 cm., and the height 0.9 cm. The cutting-margin is compressed to a sharp edge, and the thickness at the base of the crown is only 2 mm. From the general symmetry of the crown, and shallow sinus in the middle of the cutting-edge, it is to be inferred that the tooth occupied a position in the symphysial series. The area overlapped by the tooth immediately preceding on the anterior face of the crown is very plainly demarcated. The darker colored band along the cutting-margin appears to be due to fortuitous mineralization.

The present species does not appear to be at all closely related to other American or European forms, and only remotely resembles certain teeth described from the St. Louis and Chester formations under the names of *Tanaodus sculptus* and *T. polymorphus* St. J. and W. The general delicacy of the specimen is suggestive of *Peltodus unguiformis* N. and W., from the Coal Measures of Illinois, but the form and surface markings are different. Tanaodus and Peltodus are probably both synonyms of Janassa. Cope's original descriptions of *J. strigilina* and *J. gurleyana* have recently been republished with figures by E. C. Case, in the Journal of Geology, Vol. VIII., 1900.

Formation and Locality. — Atchison shales (Missourian); Cedar Creek, Nebraska.

FISSODUS St. John and Worthen.

The chief distinguishing character between this genus and Janassa is that the trenchant margin is cleft or divided into two or three broad acuminate points. The so-called Cholodus, comprising the single species *C. inaequalis*, was held by St. John and Worthen to be distinct from Fissodus in that the cutting-margin was eccentrically lobed. The circumstance that the imperfect specimens studied by these authors were unsymmetrically worn is attributable to their having occupied a position among the lateral series of the mouth in Fissodus.

Fissodus inaequalis (St. John and Worthen).

(Plate 2, Fig. 11; Plate 3, Fig. 26.)

1875. *Cholodus inaequalis* St. John and Worthen, Pal. Illinois, Vol. VI., p. 416, Pl. XIII., Figs. 4, 5.

There can be no question that the well-preserved crown shown in the accompanying illustrations is specifically identical with the fragmentary teeth from the Upper Coal Measures of Iowa and Illinois, described by St. John and Worthen as *Cholodus inaequalis*. The symmetrically formed outlines of the present specimen indicate its having pertained to the symphysial series, and by the same token those figured by St. John and Worthen occupied a lateral position. The root has been broken away from the specimen in hand, but the imbricated belt corresponding to the triturating surface in Janassa is well preserved, and exhibits four prominent, posteriorly curved folds which have become worn either by attrition during life, or by postmortem abrasion, or both.

Indications of at least one pair of rudimentary lobes appear along the lateral border half-way between the terminal apices and the plicated area. The cutting-margin is moderately thin, and below it for some distance on either face the dentine tubules have become exposed through atmospheric erosion. The marks of overlap by the tooth immediately preceding this are rather indistinctly shown. A shallow longitudinal depression occupies the middle portion of the anterior face opposite the imbricated area, a condition similar to that observed in *Janassa maxima*.

Formation and Locality. — Missourian; Peru and Louisville, Nebraska; Topeka, Kansas; also in Iowa, Illinois, and Missouri.

Fissodus dentatus, sp. nov.

(Plate 2, Fig. 12.)

Type. — Detached crown; Museum of Comparative Zoölogy.

Definition. — Teeth of comparatively small size, oval in general outline, with faintly serrated lateral border and cutting-margin divided by a median cleft into two strong, acuminate cusps. Anterior face smooth, uniformly and strongly convex in a vertical direction, more gently arched from side to side. About one-half of the anterior face overlapped by the next older tooth in front.

A small, beautifully preserved crown from the Missourian of Topeka, Kansas, collected by the late S. A. Miller, and now belonging to the Museum of Comparative Zoölogy, is taken as the type of this species, which differs from other Fissodus teeth in having serrated lateral margins. This character is of interest inasmuch as it determines Fissodus to be intermediate in position between Janassa and Ctenoptychius. The general configuration of the crown resembles that of *F. tricuspidatus*, but on the other hand it agrees with *F. bifidus* in possessing a deeply cleft, equilobed cutting-margin. There are three tolerably distinct serrations along the upper third of the lateral margin on either side, below which are several faint crimpings of the delicate edge. The posterior face is concealed by matrix, and the root has been broken away. The total height of the crown is a fraction over, and the extreme width a fraction under 7 mm.

Formation and Locality. — Missourian; Topeka, Kansas.

PETALODUS Owen.

The teeth of this genus have petal-shaped crowns which are much elongated from side to side, and shortened in the opposite direction. The cutting-margin is smooth or at most delicately crenulated, but not serrated, and the base of the crown has several narrow imbricating folds of dentine descending lower on the posterior than on the anterior face. The root is relatively large in typical species, with a tumid and truncated lower extremity, and is longest and broadest in teeth belonging to the symphysial series. The shortness of the root in some species has led to the establishment of such genera as "Antliodus" and "Chomatodus," which are best included under the same head as the more typical forms.

Although the teeth of Petalodus are scarcely distinct from those of Ctenoptychius, as already observed by Traquair,[1] practical reasons render it desirable to retain the former as a provisional genus, and besides, the uniformly entire condition of the cutting-margin in Petalodus seems to be a character of more than specific value. A serrated cutting-margin is simulated only amongst unequally worn teeth, usually belonging to the lateral series, in some species. In Ctenoptychius the teeth of both upper and lower jaws are distinctly serrated, in Peripristis only those of the upper jaw. The teeth of Petalodus are known to have been arranged in series closely similar to those of Janassa, the larger and symmetrically formed teeth occupying a symphysial position, and the lateral series diminishing in size, besides becoming more oblique, on passing from the center. Jaekel's conjecture that the symphysial series were of the form known as Petalorhynchus is clearly untenable.

Petalodus alleghaniensis LEIDY.

(Plate 2, Figs. 17, 18; Plate 3, Fig. 27.)

1853. *Petalodus ohioensis* J. M. Safford, Amer. Journ. Sci. (2), Vol. XVI., p. 142. [Insufficiently defined.]
1856. *Sicarius extinctus* J. Leidy, Proc. Acad. Nat. Sci. Philad., Vol. VII., p. 414. [Insufficiently defined.]
1856. *Petalodus alleghaniensis* J. Leidy, Journ. Acad. Nat. Sci. Philad. (2), Vol. III., p. 161, Pl. XVI., Figs. 4–10.
1866. *Petalodus destructor* J. S. Newberry and Worthen, Pal. Illinois, Vol. II., p. 35, Pl. II., Figs. 1–3.
1870. *Petalodus destructor* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 433.
1872. *Petalodus destructor* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv., Nebraska, p. 241, Pl. III., Fig. 5.
1873. *Petalodus alleghaniensis* J. Leidy, Rept. U. S. Geol. Surv. Territ., Vol. I., p. 312, Pl. XVII., Fig. 3.
1875. *Petalodus alleghaniensis* J. S. Newberry, Rept. Geol. Surv. Ohio, Vol. II., p. 52, Pl. LVIII., Fig. 13.
1875. *Petalodus alleghaniensis* St. John and Worthen, Pal. Illinois, Vol. VI., p. 396.
1895. *Petalodus securiger* O. P. Hay, Journ. Geol., Vol. III., p. 561, Figs. 1, 2.
1896. *Petalodus alleghaniensis* C. R. Eastman, Journ. Geol., Vol. IV., p. 174.
1899. *Petalodus* sp. O. Jaekel, Zeitschr. deutsch. geol. Ges., Vol. LI., p. 287, Fig. 6 A.

[1] Geol. Mag. (3) Vol. V., 1888, p. 85.

A large series of this exclusively Upper Carboniferous species have come under the writer's observation, a study of which shows a wide range of variation to exist between the large, symmetrically formed, symphysial teeth, such as is represented in Pl. **2**, Fig. 17, and the low-crowned, short-rooted, often quite asymmetrical teeth belonging to the outermost of the lateral series. The form of the root is even more variable than that of the crown, as one may satisfy himself by comparison of Figs. 17 and 18 of Plate **2**, or the other figures of this species contained in the literature. Dr. O. P. Hay has commented on the fact that in Newberry and Worthen's figures of *P. destructor* the lateral angles of the crown are acutely terminated, and notes that in the specimen named by him *P. securiger* they are rounded off, at which point the enamel folds become flexed upward. This appears to be the normal condition manifested by all perfectly preserved teeth, but the root being extremely attenuated close to the lateral angles, the edges are rarely found entire. And it is perfectly evident from Newberry and Worthen's Figs. 1–3 that none of the lateral angles in their specimens have escaped injury.

The imbricated enamel folds at the base of the crown are sometimes distinctly raised on both faces, and usually appear smoother on the anterior than on the posterior face, as if from contact with adjacent older teeth of the same series. The extent to which the teeth of a single series overlapped one another seems to have been greater than in Janassa, and equals that in Petalorhynchus[1] and Ctenoptychius.[2] Marks of wear also seem to show that the upper and lower dentition interlocked by a comparatively small margin.

Besides the single tooth of this species described by St. John from the Missourian of Rock Bluff, Nebraska, numerous examples have been obtained by Professor Barbour from the same formation at Richfield and Table Rock, and from the Permo-Carboniferous of Roca, Nebraska.

Formation and Locality. — Coal Measures; Pennsylvania, Ohio, Illinois, Iowa, Nebraska, Arkansas. Permo-Carboniferous; Nebraska.

Petalodus (Chomatodus) arcuatus (St. John).

1870. *Chomatodus arcuatus* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 435.
1872. *Chomatodus arcuatus* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 243, Pl. VI., Fig. 14.
1875. *Chomatodus arcuatus* St. John and Worthen, Pal. Illinois, Vol. VI., Pl. X., Fig. 23.

Low-crowned teeth of the form commonly ascribed to Chomatodus (*pars*) in all probability represent the postero-lateral series of Petalodus, and it would seem that this genus possessed a larger number of tranverse series than Janassa, as well as a more elongated mouth-cleft. The narrow, ray-like mouth-cleft in Janassa is regarded by Jaekel as evidence of specialization.

[1] *Cf.* J. W. Davis, On the fossil Fishes of the Carboniferous Limestone Series, Trans. Roy. Dublin Soc. (2), Vol. I., 1883, p. 426, Pl. LXI., Fig. 16.

[2] *Cf.* St. John and Worthen, Pal. Illinois, Vol. VI., 1875, Pl. XII., Fig. 9.

A single tooth of this species is described by St. John from the Missourian near Nebraska City, and another is figured by St. John and Worthen from a corresponding horizon in Adams County, Iowa. Professor Barbour has also obtained a solitary example from the Atchison shales of Peru, Nebraska.

Formation and Locality. — Missourian; Iowa and Nebraska.

Ctenoptychius occidentalis (St. John and Worthen).

(Plate 2, Fig. 10.)

1875. *Ctenopetalus occidentalis* St. John and Worthen, Pal. Illinois, Vol. VI., p. 401, Pl. XII., Fig. 14.

This species is founded on very delicate, gently arched teeth with relatively few (10–12) and obtuse coronal serrations, the broad basal band on the outer face being sharply set off from the exposed portion of the crown. The two examples known to the authors of this species were derived from the Lower Coal Measures in the vicinity of Fort Dodge, Iowa. The trivial title of *occidentalis* was bestowed by the same authors upon still another species of Ctenoptychius, which they placed in the now obsolete genus "Harpacodus." The form occurs in the St. Louis limestone of Illinois and Missouri, and so closely resembles *C. compactus* (St. J. and W.) from the Chester Group, that we have no hesitation in uniting it with that species. A single detached crown of *C. occidentalis*, somewhat weathered, was obtained by Professor Barbour from the Atchison shales of Richfield, Nebraska.

Formation and Locality. — Productive Coal Measures; Iowa. Missourian; Nebraska.

PERIPRISTIDAE.

PERIPRISTIS St. John.

Proc. Amer. Phil. Soc., Vol. XI., 1870, p. 434.

Hoplodus R. Etheridge, jun., Geol. Mag. (2), Vol. II., 1875, p. 243.
Diodontopsodus J. W. Davis, Brit. Assoc. Rept., 1881, p. 646.
Pristodus J. W. Davis (*ex* Agassiz MS.), Trans. Roy. Dublin Soc. (2), Vol. I., 1883, p. 519.

Peripristis semicircularis (Newberry and Worthen).

(Plate 2, Figs. 5–7; Plate 3, Fig. 25.)

1866. *Ctenoptychius semicircularis* Newberry and Worthen, Pal. Illinois, Vol. II., p. 72, Pl. IV., Fig. 18.

1870. *Peripristis semicircularis* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 434.

1872. *Peripristis semicircularis* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 242, Pl. III., Figs. 3, 4, Pl. IV., Fig. 20.

1875. *Ctenoptychius semicircularis* J. S. Newberry, Rept. Geol. Surv. Ohio, Vol. II., p. 52, Pl. LVIII., Fig. 14.

1902. *Peripristis semicircularis* C. R. Eastman, Geol. Mag. (IV.), Vol. IX., p. 389, Text-fig. 1.

It is evident from marks of contact that the relations between the supposed upper and lower teeth of this species are identical with those known to obtain in *P. falcatus*, a specimen of the latter having been found which displays the

FIG. 7.

Peripristis semicircularis (N. & W.). Chester Group, Kentucky. Lower tooth, in profile and front view, $\times \frac{1}{2}$.

dental plates of both jaws in natural association. The tooth which may be provisionally referred to the lower jaw in all these forms is the one which fitted inside that of the opposite jaw when the mouth was closed, this condition having been ascertained to hold in the case of Janassa, and being true among sharks generally. The lower tooth of *P. semicircularis* differs from the upper

FIG. 8.

Peripristis semicircularis (N. & W.). Chester Group, Kentucky. Upper tooth, in profile and front view, $\times \frac{1}{2}$.

in having the serrations of the cutting-edge obsolete, or nearly so, and the basal border deflected downward in the median line in front, as shown in Text-figure 7. It also has a longer root than the upper tooth. The coronal margin of the latter is always strongly serrated in the unworn condition (Text-fig. 8), there being usually four denticulations on one side of the median line and five on the other. The coronal cavity of the upper tooth exhibits a deep pit in the median line at the junction of the horizontal and vertical portions of the posterior face, but there is no groove extending from it on either side as in *P. falcatus*. In one specimen, that shown in Plate 2, Fig. 7, the pit is developed into a perforation passing entirely through the horizontal portion of the crown, a condition which is sometimes observed in *P. falcatus*. The Yorkshire species known as *P. benniei* (Etheridge) differs from both *P. falcatus* and *P. semicircularis* in that the coronal margin of the upper tooth is not dentated but smooth, and rises into an acuminate apex in front.

The original of Plate **2**, Fig. 5, possesses some pathologic interest, inasmuch as it became deformed during life, either as the result of injury or of irregularity in growth. It is an upper tooth shown here in left lateral aspect, and both root and crown on the side away from the observer are strongly indented. Fine parallel scratches resulting from the attrition of food, and preserved as distinctly as in a fresh individual, extend in the same direction over both the inner and outer coronal face on the uninjured side, and their obliquity to the vertical axis indicates that the tooth stood slantwise in the jaw, only about half the cutting-margin functioning against the lower tooth. Had its position been erect in the jaw, these markings would of course have been vertical, as in all normally formed teeth. The serrations of the cutting-margin have become almost effaced through wear. The triangular form of the root (as seen in profile) is natural, and the sublunate surface for its attachment to the crown is well shown in the original of Plate **2**, Fig. 7. The latter tooth is detachable from the matrix, thus exposing a mold of the posterior face. Impressions in the matrix show that the cutting-margin was prominently serrated, as in the original of Fig. **6** of the same plate, the root of which has not been freed from the matrix. For comparison with the Nebraska specimens shown in Plate **2**, an illustration is given in Plate **3**, Fig. 25, and also in Text-figure 8, of a large upper tooth from the summit of the Chester limestone in Kentucky. The originals of this and also of the lower tooth shown in Text-figure 7 were found by Mr. E. O. Ulrich in such close proximity at the same outcrop near Montgomery Switch, Caldwell County, as to leave scarcely any doubt that they pertained to a single individual.

Formation and Locality. — Atchison shales (Missourian); Bellevue, Nebraska City and South Bend, Nebraska. Productive Coal Measures; Ohio and Indiana. Chester Group; Caldwell County, Kentucky.

COCHLIODONTIDAE.

PLATYXYSTRODUS Hay.

The name Platyxystrodus has been proposed by O. P. Hay as a substitute for the preoccupied title of Xystrodus, the latter having been employed by Plieninger two years prior to the application of the term in 1860 by Morris and Roberts.

Platyxystrodus occidentalis (St. John).

1870. *Xystrodus (?) occidentalis* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 436.

1872. *Xystrodus (?) occidentalis* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 244, Pl. IV., Fig. 18.

This species is founded upon a single imperfect tooth, doubtfully of this genus, from the Missourian of Aspinwall, Nebraska. The general form is suggestive of Deltodus, but the coronal surface is described by St. John as exhibiting the characteristic punctations of Platyxystrodus.

Deltodus angularis Newberry and Worthen.

(Plate 2, Fig. 19.)

1866. *Deltodus angularis* Newberry and Worthen, Pal. Illinois, Vol. II., p. 97, Pl. IX., Fig. 1.

1870. *Deltodus (?) angularis* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 437.

1872. *Deltodus (?) angularis* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 244, Pl. VI., Fig. 18.

1883. *Orthopleurodus carbonarius* St. John and Worthen, Pal. Illinois, Vol. VII., p. 192, Pl. XIII., Fig. 7 (*non* Figs. 6, 8).

The forms cited in the above synonymy all plainly belong to the genus Deltodus, and hence we find ourselves unable to agree with St. John and Worthen in their proposed union of this species with Sandalodus, on the basis of three fortuitously associated teeth described by them in Volume VII. of the Illinois Palaeontology. A small posterior dental plate was obtained by St. John from the Missourian of Nebraska City, and the larger one shown in Plate **2**, Fig. 19, is from the same horizon near Louisville, Nebraska.

Formation and Locality. — Missourian; Kansas, Nebraska, Iowa, and Missouri. Lower Coal Measures; Illinois and Indiana.

Sandalodus carbonarius Newberry and Worthen.

1866. *Sandalodus carbonarius* Newberry and Worthen, Pal. Illinois, Vol. II., p. 104, Pl. X., Figs. 4, 5.

1883. *Orthopleurodus carbonarius* St. John and Worthen. *Op. cit.*, Vol. VII., p. 192, Pl. XIII., Figs. 6, 8.

1889. *Orthopleurodus carbonarius* J. P. Lesley, Rept. Geol. Surv. Penn., Vol. II., pp. 568, 920, Pl. 4.

1895. *Orthopleurodus carbonarius* J. P. Lesley, Summary Geol. Penn., Vol. III., Pl. LXXI.

Examples of this species determined by St. John and Worthen as "long posterior teeth of the upper jaw" are reported by these authors from the "Upper Coal Measure strata near Topeka, Kansas."

STREBLODUS Agassiz.

Streblodus may be conveniently retained as a provisional genus in the sense intended for its employment by Agassiz. A different interpretation has been suggested by St. John and Worthen,[1] who distribute the dental plates referred to Streblodus amongst the genera Cochliodus, Deltoptychius, and Chitonodus, but confirmation of their views by direct evidence is lacking. The same may be said regarding their theoretical reconstruction of the dentition in Deltoptychius, and we agree with Woodward[2] and others in preferring to adopt the interpretation of M'Coy[3] as amended by Davis.[4]

Streblodus angustus, sp. nov.

(Plate 2, Fig. 20, Text-figure 9.)

Type. — Posterior dental plate; Museum Nebraska State University.

Definition. — Posterior dental plate narrow and elongate, obliquely truncated in front, outer margin broadly arched, and postero-lateral border forming an acute angle with the inner margin. Posterior tumid portion of coronal surface sharply separated by an abrupt elevation from the anterior portion, and exceeding the latter in extent. Anterior portion crossed by a narrow, angulated, and very oblique ridge, with a slight thickening of the antero-lateral margin.

FIG. 9.
Streblodus angustus, sp. nov. Posterior dental plate, × ½.

The posterior dental plate upon which this species is founded has a total length of 2 cm., and width in the middle portion of 7 mm., the form being quite narrow and antero-posteriorly elongated as compared with other species. It bears a rather remote resemblance to *S. obliquus* (St. J. and W.) from the St. Louis limestone of Missouri, but is more attenuated and lacks the prominent fold along the antero-lateral border.

Formation and Locality. — Atchison shales (Missourian); South Bend, and Cedar Creek, Nebraska.

Helodus rugosus Newberry and Worthen.

(Plate 2, Fig. 14.)

1870. *Helodus rugosus* Newberry and Worthen, Pal. Illinois, Vol. IV., p. 359, Pl. II., Fig. 10.

A detached tooth obtained by Professor Barbour from the Missourian of Table Rock, Nebraska, exhibits all the characters described for this species,

[1] Pal. Illinois, Vol. VII., 1883, p. 92.
[2] Cat. Foss. Fishes Brit. Museum, Pt. i., 1889, p. 212.
[3] Brit. Palaeoz. Foss., 1855, p. 621.
[4] Trans. Roy. Dublin Soc. (2), Vol. I., 1883, p. 432.

except that the coronal surface is not roughened or vermiculated. The latter appearance may be perhaps attributed to varying conditions of wear and preservation, and is doubtfully of specific value.

PHYSONEMUS Agassiz.

The mostly small, highly tuberculated Ichthyodorulites known as Physonemus, Erismacanthus, Gampsacanthus, Dipriacanthus, etc., interpreted as lateral head-spines, may be provisionally referred to the Cochliodontidae.

Physonemus asper, nom. nov.

1859. *Xystracanthus arcuatus* J. Leidy, Proc. Acad. Nat. Sci. Philad., p. 3.
1873. *Xystracanthus arcuatus* J. Leidy, Rept. U. S. Geol. Surv. Territ., Vol. I., p. 312, Pl. XVII., Fig. 25.
1875. *Xystracanthus arcuatus* St. John and Worthen, Pal. Illinois, Vol. VI., p. 457.

The type species of Physonemus having been named *P. arcuatus* by M'Coy in 1848, it becomes necessary to designate the type of Leidy's so-called "Xystracanthus" by a new specific title on removing it to Physonemus. The name *P. asper* is accordingly proposed for it in allusion to the coarsely tuberculated style of its ornamentation. Jaekel's theoretical association of spines of this character with the teeth of Petalodus and Polyrhizodus, and also with the dermal tubercles of Petrodus, has not been proved by any direct evidence, and militates with the facts of distribution.

Formation and Locality. — Missourian ; Leavenworth, Kansas.

CESTRACIONTIDAE.

ORODUS Agassiz.

Orodus intermedius, sp. nov.

(Plate 4, Figs. 35, 36.)

Type. — Detached tooth; Museum of Comparative Zoölogy.

Teeth of medium size, upwards of 3 cm. in length. Coronal contour gradually rising into a nearly smooth dome-shaped median eminence; longitudinal crest low, slightly wavy, giving off several groups of branching transverse wrinkles extending on either side, and forming slight buttresses on the outer coronal margin; base of crown faintly crenulated along the inner margin.

The unique tooth answering to the above description was obtained by the late Mr. Samuel A. Miller from the Upper Coal Measures on the opposite side of the river from Leavenworth, Kansas, near Weston, in Platte County, Missouri. The name by which it may be designated has reference to the intermediate characters which it displays between Orodus and Campodus. The coronal surface is elevated into a median prominence, and is marked with the longitudinal and transverse ridges which are so conspicuous a feature of Orodus, but at the same time the outer coronal margin, which at the most is only faintly crenulated in other species of Orodus, is here differentiated after the manner of Campodus. It is obvious that the two genera are very closely related, but the characters by which they may be provisionally distinguished appear to warrant their separation, at least until such time as we shall have obtained a more perfect knowledge of the arrangement of the dentition in both forms.

Formation and Locality. — Missourian; Missouri River Valley.

CAMPODUS DE KONINCK.

Campodus variabilis (NEWBERRY and WORTHEN).

(Plate 1, Fig. 1; Plate 2, Figs. 15, 16.)

1870. *Lophodus variabilis* Newberry and Worthen, Pal. Illinois, Vol. IV., p. 361, Pl. IV., Figs. 4, 5, 11.

1875. *Agassizodus variabilis* St. John and Worthen, *Op. cit.* Vol. VI., p. 318, Pl., VIII., Figs. 1-22.

1883. *Agassizodus variabilis* M. Lohest, Ann. Soc. Geol. Belg., Vol. XI., p. 305, Text-figs. 1, 3.

1901. *Campodus variabilis* C. R. Eastman, Science, Vol. XIV., p. 795.

1902. *Campodus variabilis* C. R. Eastman, Geol. Mag. (4), Vol. IX., p. 148, Pl. VIII., Fig. 1.

1902. *Campodus variabilis* C. R. Eastman, Bull. Mus. Comp. Zool., Vol. XXXIX., p. 57, Pls. I. II., Pl. IV., Fig. 1.

Detached teeth of this species are of not infrequent occurrence in the Missourian of Iowa, Kansas, and Nebraska, and in two or three instances a large part of the dentition has been found in natural association. The complete dentition of one jaw (presumably the lower) is known from a series of interesting specimens, the most important of which was first described by St. John and Worthen in Volume VI. of the Palaeontology of Illinois, and has been since re-investigated by Max Lohest and the present writer. The original of this magnificent specimen is now preserved in the private collection of Mr. Frank Springer, and casts made from it by St. John in 1874 are in existence in a number of museums. One of these plaster casts was utilized in the construction of the model shown in Plate 1, which represents the restored dentition, the symphysial series in front being photographed from an actual specimen belonging to the Museum of Nebraska State University.

The nearly complete ramus of the lower jaw described by St. John and

Worthen exhibits upwards of 450 teeth disposed in about 18 transverse series, the smallest teeth occurring toward the extremities, and increasing gradually in size toward the middle of the ramus. The series are arranged after the same general pattern as in Cestracion, as is evident from a comparison of the two figures given in Plate 1, Fig. 2 being from a photograph of the lower jaw of *Cestracion francisci* Girard.

For a description of the two examples of the symphysial series which are known, reference may be had to a previous number of the Museum Bulletin, Vol. XXXIX., No. 3, and it need only be restated here that each individual

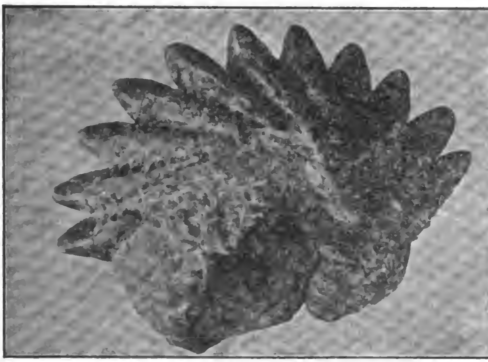


Fig. 10.

***Campodus variabilis* (N. & W.). Atchison shales, Cedar Creek, Nebraska. Lower symphysial dentition, $\times \frac{4}{5}$.**

of Campodus possessed at least three series of coalesced anterior or symphysial teeth. As indicated by the marks of contact, there was a median arched azygous series in one jaw, presumably the lower, opposed to which in (presumably) the upper were two corresponding series separated from each other by a slight interval and mutually interlocking with the former. Each of these series (Text-fig. 10) comprises from 11 to 13 enormously enlarged teeth which are fused into an arch corresponding to that of Edestus and Campyloprion, and to the thrice-coiled spiral of Helicoprion, all of which genera are to be regarded as highly specialized Cestraciont sharks.

This enlargement of the symphysial series seems to be a hypertrophic character peculiar to Palaeozoic forms, first appearing in the Devonian Protodus, and disappearing, so far as known, with Helicoprion in the Permian of Russia, India, and Japan. Occasionally the median azygous series of the lower jaw in *Cestracion philippi* is slightly enlarged, possibly through atavism. The ancient family of Cestraciontidae to which all these forms belong is remarkable not only for its astonishing longevity, almost unparalleled amongst fishes, but also for its prolific offshoots during Palaeozoic and Mesozoic times. The great groups of Cochliodonts, Orodonts, Acrodonts, and Hybodonts may all be considered as derivatives from the Cestraciont stem, and it is probable that the modern ray-type is also descended from the same lineage.

The great variety in form manifested by the lateral teeth of *C. variabilis*, as implied by the specific title, has been well illustrated by St. John and Worthen. Some of the posterior series bear a strong resemblance to those of Orodus, but are distinguished by the buttressed condition of the coronal border and the less acuminate character of the series of lateral teeth. Only Jaekel has expressed an opinion that Orodus and Campodus are not generically distinct, and are intimately related to Psephodonts and Psammodonts.[1] Examples of detached teeth of *C. variabilis* are shown in Plate **2**, Figs. 13 and 14, the latter agreeing very closely with St. John and Worthen's Plate VIII., Fig. 4, of the sixth volume of the Illinois Palaeontology.

Formation and Locality. — Missourian ; Kansas, Nebraska, Iowa, and Illinois.

Ctenacanthus amblyxiphias Cope.

(Plate 2, Figs. 22, 23.)

1891. *Ctenacanthus amblyxiphias* E. D. Cope, Proc. U. S. Nat. Museum, Vol. XIV., p. 449, Pl. XXVIII., Fig. 3.

This species was originally described from the Permian of Texas, and does not appear to have been recognized up to the present time outside of the typical locality. The two fragmentary spines obtained by Professor Barbour are from the Missourian of South Bend and Louisville, respectively, in Nebraska. This form has a more angular cross-section than most of the Mississippian species of Ctenacanthus.

DIPNOI.

CTENODONTIDAE.

Sagenodus copeanus Williston.

1899. *Sagenodus copeanus* S. W. Williston, Kansas Univ. Quart., Vol. VIII., p. 178, Pl. XXXV.-XXXVII.

This species is known by the upper dentition and a number of associated bones from the Missourian of Brown County, Kansas.

[1] Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 296.

CROSSOPTERYGII.

OSTEOLEPIDAE.

Megalichthys macropomus Cope.

1902. *Megalichthys macropomus* E. D. Cope, Proc. Amer. Phil. Soc., Vol. XXX., p. 226, Pl. VIII.

It is stated in the original description that this species is "established on the greater part of an individual from the Carbonic system of Kansas," then contained in the private collection of R. D. Lacoe. Fragments of another individual from the Leavenworth Coal near Lansing, Kansas, were obtained by Mr. O. H. St. John a number of years ago, and are now preserved in the Museum of Comparative Zoölogy. Two other species of Megalichthys have been described by Cope from the Permian of Texas.

LIST OF FOSSIL FISHES OCCURRING IN THE UPPER CARBONIFEROUS OF KANSAS AND NEBRASKA.

ELASMOBRANCHII.

1. *Pleuracanthus* (*Diplodus*) *compressus* Newb.
2. *Cladodus occidentalis* Leidy.
3. " *knightianus* (Cope).
4. *Phoebodus knightianus* Eastman.
5. *Janassa maxima* Eastman.
6. " *unguicula* Eastman.
7. *Fissodus dentatus* Eastman.
8. " *inaequalis* (St. J. and W.).
9. *Petalodus alleghaniensis* Leidy.
10. *P.* (*Chomatodus*) *arcuatus* (St. John).
11. *Ctenoptychius occidentalis* St. J. and W.
12. *Peripristis semicircularis* (N. and W.).
13. *Platyxystrodus occidentalis* (St. John).
14. *Deltodus angularis* N. and W.
15. *Sandalodus carbonarius* N. and W.
16. *Streblodus angustus* Eastman.
17. *Helodus rugosus* N. and W.
18. *Physonemus asper* Eastman.
19. *Orodus intermedius* Eastman.
20. *Campodus variabilis* (N. and W.).
21. *Ctenacanthus amblyxiphias* Cope.

DIPNOI.

22. *Sagenodus copeanus* Williston.

CROSSOPTERYGII.

23. *Megalichthys macropomus* Cope.

II. THE CARBONIFEROUS FISH-FAUNA OF MAZON CREEK, ILLINOIS.

Of the thousands of fossiliferous ironstone nodules of Coal Measure age, occurring at Mazon Creek, near Morris, in Grundy County, Illinois, only a small percentage yield indications of vertebrate remains, and these consist principally of detached fish-scales. Occasionally, however, complete individuals of fossil fishes, and in still fewer instances, Amphibian skeletons have been brought to light, but all told the number of even tolerably perfect specimens preserved in different museums is very insignificant. Probably the two finest series of Mazon Creek nodules ever brought together are the Lacoe collection, belonging to the United States National Museum at Washington, and the S. S. Strong collection, purchased by the late Prof. O. C. Marsh for the Yale Museum. Shortly before the decease of Professor Marsh, nearly all of the fossil fishes in the Strong collection were placed by that gentleman in the hands of the writer for investigation; and more recently some additional material has been loaned for the same purpose by Prof. C. E. Beecher, to whom grateful acknowledgments are hereby rendered.

Mazon Creek fish-scales have been exhaustively studied by E. D. Cope [1] and O. P. Hay,[2] and the latter has also described a nearly perfect example of a Palaeoniscid fish, named by him *Elonichthys hypsilepis*. Other Palaeoniscids and Platysomids have been described by Cope,[3] Newberry and Worthen,[4] and the present writer,[5] and the latter has also published descriptions of one Coelacanth and two Acanthodian species.[6] These citations complete the literature references on Mazon Creek fishes. In the following paragraphs a few new species are described, and the structure of certain Ganoids is examined more in detail than has been done heretofore.

DIPNOI.

CTENODONTIDAE.

Sagenodus cristatus, sp. nov.

(Plate 3; Fig. 30.)

Type. — Palatine dental plate; Yale Museum.

Upper dental plate relatively short and broad, attaining a length of about 5 cm. and a maximum breadth of 3.5 cm. Outer margin nearly straight; coronal

1 Proc. Amer. Phil. Soc., Vol. XXXVI., 1897, pp. 71–82.
2 *Ibid.*, Vol. XXXIX., 1900, pp. 96–120.
3 Proc. U. S. Nat. Museum, Vol. XIV., 1891, p. 462.
4 Pal. Illinois, Vol. II., 1866, and Vol. IV., 1870.
5 Journ. Geol. Vol. X., 1902, p. 450.
6 Bull. Mus. Comp. Zool., Vol. XXXIX., 1902, pp. 93–94.

surface slightly concave, with at least seven prominent, rather broad and coarsely tuberculated ridges, the tubercles gradually decreasing in size from the abrupt outer towards the narrow inner margin.

This species is represented by a unique upper dental plate belonging to the Yale Museum, which is readily distinguished from other species by its abbreviate form and nearly straight parallel ridges. The tuberculations of the latter are coarser and less acuminate than in *S. vabasensis* Cope,[1] and the ridges resemble some species of Ctenodus in their non-radiating character. A narrow and elongate cranial plate, having the dimensions of 5 by 10 cm., and belonging to the same collection, may perhaps be correlated with this species. All other Dipnoan remains from the Mazon Creek locality are founded on detached scales.

Formation and Locality. — Coal Measures ; Mazon Creek, Illinois.

CROSSOPTERYGII.

COELACANTHIDAE.

COELACANTHUS Agassiz.

J. S. Newberry[2] records having received from Mazon Creek "a single specimen each of *Eurylepis* and *Coelacanthus*, probably not distinct from those found at Linton," Ohio. No examples of the former genus have come under the writer's observation, but ornamented scales and head-plates referable to Coelacanthus sometimes occur in Mazon Creek nodules, and very rarely there are found complete fishes of small size, evidently quite distinct from those occurring elsewhere. In most specimens the posterior dorsal, anal, and pectoral fins are wanting, and one might be led to suppose at first that the second dorsal had become lost through specialization. A single example preserved in the Museum of Comparative Zoölogy shows it very distinctly, however, and the absence of this and the anal fin in other examples is therefore attributable to faulty preservation.

Coelacanthus exiguus Eastman.

(Plate 5, Fig. 48.)

1902. *Coelacanthus exiguus* C. R. Eastman, Journ. Geol. Vol. X., p. 538, Text-fig. 3.

Type. — Complete individual; Yale Museum.

A small species, attaining a maximum length of about 4.5 cm. Trunk narrow and elongated, the head occupying about one-fourth of the total length. First dorsal consisting of relatively few stout rays, and situated slightly in

[1] Journ. Geol. Vol. VIII., 1900, p. 704, Pl. 1, Fig. 7.

[2] Mon. U. S. Geol. Surv., Vol. XVI., 1889, p. 215.

advance of the pelvic pair; second dorsal midway between the anterior dorsal and principal caudal; the latter comprising nine stout rays above and below. Scale structure and ornamentation of head-bones not observed.

This species is represented by ten specimens in the Yale and one in the Harvard Museum, most of them being only about 3 cm. long, and very deficient in preservation. They agree in having a narrow, gradually tapering body, which terminates in an equilobate caudal fin, with indications that the axis was prolonged into a supplementary caudal. The anterior dorsal and caudal, owing to their firmer attachment, are preserved in nearly all specimens, but the remaining fins have in most cases become lost. The first dorsal has usually seven or eight stout rays, and is situated near the middle of the trunk. Ten long, hollow rays are to be counted in the single specimen displaying the posterior dorsal, and nine above and below in the symmetrical caudal. The neural and haemal spines are very long in the abdominal and caudal regions. The ossifications of the axial skeleton are continued nearly to the termination of the principal caudal. The squamation must have been exceedingly delicate, as no indications of scales are to be observed in any of the specimens, nor do any of them have the cranial elements satisfactorily preserved.

Formation and Locality. — Coal Measures; Mazon Creek, Illinois.

ACTINOPTERYGII.

PALAEONISCIDAE.

ELONICHTHYS Giebel.

Two closely related species are already known from Mazon Creek, *E. peltigerus* Newberry, and *E. hypsilepis* Hay. A study of the type specimen of Newberry and Worthen's so-called "*Amblypterus macropterus*," now preserved in the Yale Museum, leaves no doubt that this is only a mutilated individual of *E. peltigerus*. The type of *Rhadinichthys gracilis* (Newberry and Worthen) is also preserved in the Yale Museum.

Elonichthys perpennatus Eastman.

(Plate 5, Fig. 49.)

1902. *Elonichthys perpennatus* C. R. Eastman, Journ. Geol., Vol. X., p. 539, Text-fig. 4.

Type. — Complete individual; Museum of Comparative Zoölogy.

A very small species, having a total length of about 2.5 cm. of which the head occupies a little less than one fourth. Fins extremely well developed, the pectorals unusually long, and anal much extended; fulcra minute. Scales relatively small, obliquely striated; dorsal ridge-scales enlarged.

The solitary known and probably immature example of this species is shown of twice the natural size in Plate **5**, Fig. 49. The head is poorly preserved, and the extremities of nearly all the fins are either broken away or obscured by matrix. Nevertheless sufficient characters remain for the recognition of this as a distinct species of Elonichthys, its chief peculiarity consisting in the remarkable development of all the fins. The pectorals are fully one fourth as long as the entire body, and the anal has a more extended base-line than in any other species of the genus. The dorsal appears to have been high and acuminate, but is largely concealed by matrix. The caudal is also unfavorably exposed, and flexed out parallel with the main axis, but it is plain that the upper lobe was much prolonged, and covered with very large, striated ridge-scales. The dorsal fin-rays appear to have been widely jointed; the articulations of the other fins are not clearly discernible. The dermal rays of the anal and lower lobe of the caudal are directly supported by the enlarged haemal spines, which are firmly united with their arches. The squamation is nowhere well preserved, but is best indicated in the anterior part of the trunk. The cranial structure does not admit of particular description.

Elonichthys disjunctus, sp. nov.

(Plate 3, Fig. 31.)

Type. — Distorted individual; Yale Museum.

A species of about the same size as *E. peltigerus* and *E. hypsilepis*, and resembling them in general form and ornamentation, but differing in the position of the anal and structure of the paired fins. The latter are relatively shorter in the present species, and have fewer rays. The dorsal and anal are of about equal size, triangular and acuminate, and each with 25 or more rays. The anal is inserted opposite the middle of the dorsal, and its base-line terminates at a distance in advance of the caudal at least as great as the depth of the caudal pedicle. Caudal fin deeply forked and very finely divided; fulcra minute.

Several examples of this species are preserved in the Yale Museum, the smallest having a length of only 2.5 cm., and the largest upwards of 11 cm. While exhibiting the same proportions as *E. peltigerus* and *E. hypsilepis*, it differs in the less remote position of the anal fin. One specimen in the collection shows very perfectly the two series of piercing teeth, and about 14 branchiostegal rays. The original of Plate **3**, Figure 31, which is selected as the type, has the body flexed in such wise as to present the ventral aspect of the head and greater portion of the trunk, while the region behind the anal fin is seen from the right-hand side. The caudal is very well shown; the anal, on the other hand, is somewhat distorted, and the dorsal and paired fins are wanting.

Formation and Locality. — Coal Measures; Mazon Creek, Illinois.

PLATYSOMATIDAE.

Three unique specimens from the Mazon Creek locality, all more or less imperfectly figured and described, have been referred to as many species of Platysomus, and a fourth species has been described by Cope (*P. palmaris*) from the Permian of the southern part of Indian Territory. The characters of the so-called *P. orbicularis* Newberry and Worthen have never been defined, and the type specimen is here regarded as pertaining to Cheirodus.

Platysomus circularis Newberry and Worthen.

(Plate 5, Fig. 51.)

1870. *Platysomus circularis* Newberry and Worthen, Pal. Illinois, Vol. IV., p. 347, Pl. IV., Fig. 2.

Type. — Complete fish; Illinois State University, Urbana.

A very small species, attaining a maximum length of about 4 cm. Outline of body elliptical, greatest depth of trunk exceeding its length from the pectoral arch to the base of the caudal fin, and more than twice as long as the head with opercular apparatus; dorsal margin gibbously rounded from the occiput to the narrow caudal pedicle, ventral margin regularly rounded. Dorsal and anal fins arising considerably behind the middle of the back, relatively high, and extending close to the origin of the caudal fin. Scales finely striated, the striae being parallel, even, and regular, vertical on those situated nearest to the ventral margin in advance of the anal fin, but oblique on the remaining longitudinal rows.

In the original figure of this species, the squamation is very distinctly shown, and the scales are described as being "oblong in outline, smooth, those on the sides three to six times as high as long." An examination of the type, however, kindly permitted by Prof. C. W. Rolfe, reveals the fact that the scales are very inaccurately drawn, and that their striated condition was overlooked by the authors. Several examples, clearly belonging to this species, are preserved in the Yale Museum, one of which has been selected for illustration in the accompanying plates, and the definition of the species has been amended in conformity with characters displayed by the additional material. The dorsal and anal fins are stated by Newberry and Worthen as consisting of forty and thirty dermal rays, respectively, but it is probable that even more than this number were present.

Formation and Locality. — Coal Measures; Mazon Creek, Illinois.

CHEIRODUS M'Coy.

Cheirodus orbicularis (Newberry and Worthen).

(Plate 5, Fig. 52.)

1870. *Platysomus orbicularis* Newberry and Worthen, Pal. Illinois, Vol. IV., Pl. III., Fig. 1. (No description.)

A number of specimens in the Yale Museum agree with the figure published by Newberry and Worthen in having an orbicular body with scales arranged in very narrow vertical bands. The identity of these specimens with the type of *Platysomus orbicularis* is further confirmed by the fact that one of them is so labelled in Newberry's handwriting. The unsatisfactory illustration of this species induces a suspicion that the type was very imperfectly preserved, in which case it is not to be wondered that the authors failed to observe the dorsal and ventral peaks exhibited by other specimens. A study of all available material enables me to give the following amended definition of this species.

A small species, attaining a maximum length of about 4.5 cm. Trunk deep, orbicular in outline, the dorsal margin elevated into a prominent peak at about its middle point, and the ventral margin angulated to a somewhat lesser extent at a point about midway between the branchial apparatus and the narrow caudal pedicle. Facial contour of head steep, cranial plates granulated and striated; the head with opercular apparatus contained about two and one-half times in the total length to the base of the caudal fin. Dorsal and anal fins arising at a considerable distance behind the marginal peaks, and extending close to the origin of the caudal fin; the latter nearly equilobate, its upper lobe with well-developed fulcra, and its width at distal extremity equalling about one third the maximum depth of trunk. Dorsal fin with fifty or more rays, caudal and anal each with a somewhat lesser number. (Paired fins not observed.)

Scales ornamented externally with faint longitudinal striae and usually one longitudinal ridge situated near the anterior border of each scale; attached surface coarsely striated, the striae being nearly vertical on the deeper flank-scales, but oblique on those situated dorsally and ventrally and in the caudal region. Scales of the anterior part of the trunk arranged in nearly vertical narrow bands, those toward the tail showing a slight downward and backward obliquity, and those at the base of anal fin reflexed forwards toward the ventral margin.

Formation and Locality. — Coal Measures; Mazon Creek, Illinois.

LIST OF CARBONIFEROUS FISHES OCCURRING AT MAZON GREEK, ILLINOIS.

ELASMOBRANCHII.

1. *Pleuracanthus* (*Diplodus*) *compressus* Newb. (Occurs also at Linton, Ohio, and in Indiana.)
2. " " *latus* Newb. (Occurs also at Linton, Ohio, and in Indiana.)
3. " " *lucasi* Hay.
4. *Acanthodes beecheri* Eastm.
5. " *marshi* Eastm.
6. *Campodus scitulus* (St. J. and W.).

DIPNOI.

7. *Ctenodus* sp. indes.
8. *Sagenodus cristatus* Eastm.
9. " *foliatus* Cope.[1]
10. " *lacovianus* Cope.[1]
11. " *occidentalis* (Newb. and W.)[1] (Occurs also at Linton, Ohio.)
12. " *quadratus* (Newb.)[1] (Occurs also at Linton, Ohio.)
13. " *quincunciatus* Cope.[1]
14. " *reticulatus* (Newb. and W.)[1]
15. " *textilis* Hay.[1]

CROSSOPTERYGII.

16. *Rhizodopsis* (?) *mazonius* Hay.[1]
17. *Coelacanthus exiguus* Eastm.
18. " *robustus* Newb.[1] (Occurs also at Linton, Ohio.)

ACTINOPTERYGII.

19. *Eurylepis*, sp. indet. (*fide* J. S. Newberry).
20. *Rhadinichthys gracilis* (Newb. and W.).
21. *Elonichthys disjunctus* Eastm.
22. " *hypsilepis* Hay.
23. " *peltigerus* Newb.[2] (Occurs also at Linton, Ohio).
24. " *perpennatus* Eastm.
25. *Platysomus circularis* Newb. and W.
26. " *lacovianus* Cope.
27. *Cheirodus orbicularis* (Newb. and W.).

[1] Founded on scales.

[2] Including also the so-called "*Amblypterus macropterus*" Newb. and W.

III. SPECIES OF FOSSIL FISHES FROM THE MISSISSIPPIAN SERIES.

Under this head descriptions are given of several new species from the Kinderhook and Keokuk limestones of the Mississippi Valley, and the structure and systematic relations of certain others are considered concerning which a difference of opinion amongst authors has existed. For an opportunity to examine some of the type specimens described in the Palaeontology of Illinois the writer is indebted to the courtesy of Prof. C. W. Rolfe, of the State University at Urbana, and to Mr. C. H. Crantz, Curator of the State Museum at Springfield, Illinois.

The following table shows the commonly accepted subdivisions of the Mississippian series for this region: —

SECTION OF THE LOWER CARBONIFEROUS.

Mississippian Series.	Genevieve Group or Stage.	Chester limestone and shales (including the "Kaskaskia limestone").
		St. Louis limestone.
		Warsaw limestone (in part).
	Augusta (Osage) Group or Stage.	Keokuk limestone.
		Burlington limestone.
	Kinderhook Group or Stage.	Chouteau limestone.
		Hannibal shales.
		Louisiana limestone.

ELASMOBRANCHII.

PLEURACANTHIDAE.

PHOEBODUS St. John and Worthen.

Of this genus three species are represented in the Devonian of this country, two in the Mississippian series, and one in the Permo-Carboniferous, including those described in the present paper. It is probable, however, that at least two forms ascribed by Newberry and Worthen to the "genus" Diplodus, namely, *D. incurvus* and *D. duplicatus*, should be referred to Phoebodus as commonly understood.

Phoebodus dens-neptuni, sp. nov.

(Plate 4, Fig. 39.)

Type. — Detached tooth ; Museum of Comparative Zoölogy.

Teeth of moderate size, with three principal cones less than one cm. in height. Median cone erect, gradually tapering, lateral cones of unequal height, gently curved outward toward the apex ; all three delicately striated, subcircular in cross-section, the median broader than the others.

This species is founded upon a unique tooth from the Keokuk limestone of Iowa, which seems to be intermediate in character between the so-called *Diplodus incurvus* and *D. duplicatus* of Newberry and Worthen accompanying it in the same horizon. From the former it is distinguished by its more slender form and striated cones, and from the latter by its possession of three principal cones instead of four, as in that species. The nature of the base is not determinable from the solitary example that is known of the present species.

Formation and Locality. — Keokuk limestone ; Keokuk, Iowa.

COCHLIODONTIDAE.

A deal of confusion exists regarding the nomenclature of certain species of Sandalodus, Deltodus, and Deltoptychius occurring in the Carboniferous rocks of the Mississippi Valley, a state of affairs which is attributable to the imperfect preservation of the greater number of their remains. A study of a large collection of Cochliodont teeth belonging to the Museum of Comparative Zoölogy and the United States National Museum has suggested the following synonymy in the case of several disputed species.

SANDALODUS Newberry and Worthen.

Sandalodus laevissimus Newberry and Worthen.

(Text-figure 11.)

1866. *Sandalodus laevissimus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 104, Pl. X., Figs. 6–8.

1866. *Sandalodus grandis* Newberry and Worthen, *Ibid.*, p. 105, Pl. X., Fig. 9.

1866. *Deltodus grandis* Newberry and Worthen, *Ibid.*, p. 101, Pl. IX., Fig. 9.

1866. *Cochliodus ? crassus* Newberry and Worthen, *Ibid.*, p. 91, Pl. VIII., Fig. 2.

1866. *Psammodus ? semicylindricus* Newberry and Worthen, *Ibid.*, p. 109, Pl. XI., Fig. 4.

1866. *Psammodus ? rhomboideus* Newberry and Worthen, *Ibid.*, p. 110, Pl. XI., Fig. 6.

(?) 1879. *Deltodus grandis* J. S. Newberry, Ann. Rept. Geol. Surv. Indiana, 1876–78, p. 344.

1883. *Sandalodus laevissimus* St. John and Worthen, Pal. Illinois, Vol. VII., p. 186, Pl. XII., Figs. 8, 9 (and 5?).
1897. *Deltodus grandis* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 297.
1900. *Sandalodus laevissimus* C. R. Eastman, Amer. Nat., Vol. XXXIV., p. 581, Fig. 1.
1902. *Sandalodus laevissimus* O. H. St. John, Amer. Nat., Vol. XXXVI., p. 659.

This species is very abundant in the Keokuk limestone of Iowa, Illinois, and Missouri, numerous perfect examples being known of both the posterior and anterior dental plates of upper and lower jaws. Most of the posterior dental plates have suffered the loss of the initial coiled portion, which is remarkable for being wound upon itself one and one-half times before expanding into the functional grinding surface characterizing the adult, as shown in the adjoining text-figure. The upper posterior dental plate resembles in a general way that of *S. morrisii* Davis, and is much less plicated than the lower. There can be no doubt as to the correctness of St. John and Worthen's conclusion that the type of *Deltodus grandis* Newb. and Worth. is identical with this species, hence we are unable to agree with the views expressed on this subject in the posthumous paper of Newberry.[1]

Fig. 11.
Sandalodus laevissimus N. and W. Keokuk limestone, Keokuk, Iowa. Posterior dental plate of left mandibular ramus, × ⅔.

Dr. O. P. Hay is evidently mistaken in his remark that no type of the genus Sandalodus has been specified,[2] for *S laevissimus* is expressly designated as such by St. John and Worthen in their general observations on teeth of this form.[3] Dr. Hay is also in error, we believe, when he discards the specific title of *S. laevissimus* in favor of *S. crassus*. But possibly this may be due to an oversight on his part, since the original description of *S. laevissimus* with its accompanying illustrations — that which heads the list in the above synonymy — is omitted by him in his citations of the literature references.[4]

[1] Trans. N. Y. Acad. Sci., Vol. XVI., 897, p. 297.
[2] Bibliography and Catalogue of the Fossil Vertebrata of North America. Bull. U. S. Geol. Surv., No. 179 (1902), p. 288.
[3] Pal. Illinois, Vol. VII. (1883), p. 184.
[4] *Loc. cit.*, p. 289.

Sandalodus complanatus (Newberry and Worthen).

1866. *Deltodus complanatus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 98, Pl. IX., Fig. 4.
1866. *Trigonodus major* Newberry and Worthen, *Ibid.*, p. 112, Pl. XI., Figs. 8, 9.
1870. *Deltodus complanatus* Newberry and Worthen, *Ibid.*, Vol. IV., Pl. III., Figs. 5, 8 (and 12 ?).
1883. *Sandalodus complanatus* St. John and Worthen, *Ibid.*, Vol. VII., p. 184, Pl. XII., Figs. 1-4.

Much discussion has arisen as to whether the fragmentary teeth described as "*Deltodus complanatus*" are truly referable to that genus, or belong to Sandalodus. A study of a considerable amount of material from the Burlington Group has convinced the writer that the above synonymy, which is taken from St. John and Worthen, is correct, and that the teeth figured as *D. complanatus* in the posthumous paper of Newberry [1] are fragments of *D. occidentalis* N. and W.

DELTODUS Agassiz.

Two species of Deltodus are found in mutual accompaniment throughout both the Burlington and Keokuk divisions of the Mississippian, and although their extreme forms are quite distinct (Plate **4**, Figs. 38, 42), they are connected by intermediate gradations (Plate **5**, Fig. 53), so that in the case of fragmentary teeth it is sometimes difficult to determine which of the two species is represented. Generally speaking, the teeth from the Burlington limestone are less perfectly preserved than those from the Keokuk, and chiefly for this reason the synonymy has become more or less involved. We propose to recognize the two forms under the names of *D. spatulatus* Newb. and Worth. and *D. occidentalis* (Leidy) respectively. The first-named ranges from the Kinderhook to the Keokuk inclusive, and the latter from the Burlington to the St. Louis Group, being particularly abundant in the Keokuk and Warsaw beds.

Deltodus spatulatus Newberry and Worthen.

(Plate 4, Figs. 41, 42; Plate 5, Fig. 55.)

1866. *Deltodus spatulatus* Newberry and Worthen, Pal. Ill., Vol. II., p. 100, Pl. IX., Fig. 7.
1870. *Deltodus spatulatus* Newberry and Worthen, *Op. cit.*, Vol. IV., Pl. III., Fig. 11.
1870. *Deltodus alatus* Newberry and Worthen, *Ibid.*, p. 368, Pl. II., Fig. 6.
1870. *Cochliodus costatus (pars)* Newberry and Worthen, *Ibid.*, p. 364, Pl. III., Fig. 12 (*non* Fig. 10).
1879. *Deltodus spatulatus* J. S. Newberry, Ann. Rept. Geol. Surv. Indiana, 1876-78, p. 346.

[1] Trans. N. Y. Acad. Sci., Vol. XVI., 1897, p. 298, Pl. XXIV., Figs. 1-7.

1883. *Deltodopsis ? convolutus* St. John and Worthen, Pal. Illinois, Vol. VII., p. 165, Pl. XI., Figs. 11, 12.

1883. *Cochliodus costatus* (*pars*) St. John and Worthen, *Ibid*, p. 167.

1897. *Deltodus spatulatus* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 299, Pl. XXIV., Figs. 8–11.

This species was originally described from the Burlington limestone of Quincy, Illinois, and the fact that it possessed a continuous range from the Kinderhook to the Keokuk inclusive has not previously been made known. In the earliest horizon the teeth are sparse and of relatively small size; in the Burlington group it is perhaps the most profuse of all Deltodus teeth; and although moderately large forms, such as is shown in Plate **4**, Fig. 41, are occasionally met with in the Keokuk limestone, none are found in subsequent formations.

Of the posterior dental plates, the more strongly arched forms may be provisionally referred to the lower, and the less strongly arched to the upper jaw. The anterior dental plates belonging to this species have not been heretofore definitely recognized as such, no specimens having been found which show the two principal plates in natural association. An examination of a considerable amount of perfect material, however, has satisfied the writer that the strongly inrolled teeth described by St. John and Worthen under the name of *Deltodopsis ? convolutus*, and by Newberry and Worthen as the "second" tooth of *Cochliodus costatus*, fulfil all theoretical requirements for the anterior dental plate of *D. spatulatus*, and may be referred with utmost confidence to that species. The superficial characters of the two forms are identical, as already observed by St. John and Worthen, they are of corresponding proportions and curvature, and there is a perfect coadaptation of their grooved lateral edges, as any one may be convinced by fitting the two forms together in their natural position.

According to the view here advocated, the species known as *Deltodopsis ? convolutus* St. J. and Worthen becomes synonymous with *D. spatulatus*; and on removing from the so-called *Cochliodus costatus* Newb. and Worth. the form described by these authors as the "second" tooth, there remains as type of the latter species the narrow, doubly plicated form described by them as the "third" tooth. St. John and Worthen have expressed the opinion that the original authors were mistaken in regarding this as a "third," or posterior dental plate, believing it to represent the anterior of the two principal grinding plates; but evidence is lacking for associating it with any degree of assurance with other described species.

From the circumstance that the antero-lateral margin of the "second" or anterior dental plate in *D. spatulatus* is deeply grooved, as if for ligamentous union with a contiguous plate, Newberry and Worthen were led to infer the existence of a single dental element in advance of this "second" plate, thus postulating one more than the number of grinding organs characterizing the dentition of all Cochliodonts so far as known. *Cochliodus latus* Leidy furnishes us with perhaps the most complete example of Cochliodont dentition that has come to light, and analogy with this form leads us to expect in advance of the anterior dental plate a series of Helodus-like teeth on either side above and below, and in front of these at the symphysis in at least one jaw, a series of bilaterally symmetrical teeth, arched in a single plane, and corresponding to the form described by Newberry as *Helodus coxanus.*[1] We are not yet in possession of adequate material, however, to attempt a theoretical restoration of the dentition of Deltodus, and the final solution of the problem must await the discovery of naturally associated parts.

In order that students may observe for themselves the nature of the material upon which the above identifications and conclusions are based, several specimens of Deltodus teeth are figured in the accompanying plates. In Plate **4**, Fig. 38, is shown a small-sized but very perfect example of the posterior dental plate of *D. occidentalis;* in Plate **5**, Fig. 53, a specimen of the form corresponding to the so-called *D. latior* St. J. and Worth. which we regard as a variety of *D. occidentalis* transitional between that species and *D. spatulatus;* and in Plate **4**, Figs. 41, 42, are shown two rather large-sized examples of the posterior dental plate of *D. spatulatus,* one from the Burlington, and one from the Keokuk beds. Finally, in Plate **5**, Fig. 55, a very excellent example is represented of the anterior dental plate of *D. spatulatus,* according to our interpretation of the so-called *Deltodopsis? convolutus* St. J. and W. As to the size attained by the posterior dental plates of *D. spatulatus,* we can only affirm that no specimens are known exceeding that figured by Newberry and Worthen under the name of *D. alatus,* but one of almost equal proportions is preserved in the Museum of the State University of Iowa at Iowa City.

Formation and Locality. — Kinderhook. Burlington, and Keokuk Groups; Iowa, Illinois, and Indiana.

Deltodus occidentalis (Leidy).

(Plate 4, Fig. 38; Plate 5, Fig. 53.)

1857. *Cochliodus occidentalis* J. Leidy, Trans. Amer. Phil. Soc. (2), Vol. XI., p. 88, Pl. V., Figs. 3–16.
1866. *Deltodus stellatus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 97, Pl. IX., Fig. 2 (*non* Fig. 3?).
1883. *Deltodus occidentalis* St. John and Worthen, *Op. cit.*, Vol. VII., p. 150, Pl. IX., Fig. 9 (*non* Fig. 10).
1883. *Deltodus latior* St. John and Worthen, *Ibid.*, p. 145, Pl. IX., Figs. 11, 12.
1883. *Deltodus intermedius* St. John and Worthen, *Ibid.*, p. 153, Pl. IX., Figs. 14, 15.
1897. *Deltodus complanatus* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 298, Pl. XXIV., Figs. 1–7.

The teeth referred to this species exhibit a wide range of variation, and while the more common expressions are quite distinct, there are arched forms like the type of the so-called "*D. latior*" which appear to connect the species

[1] Trans. N. Y. Acad. Sci., Vol. XVI, 1897, p. 301, Pl. XXIV., Fig. 24.

with *D. spatulatus*. In Plate 4, Fig. 38, is shown a very perfect posterior dental plate of the typical form, rather under the average size. Some very large examples have a width along the antero-lateral margin of nearly 6 cm., and in these much worn teeth the coronal contour is decidedly flatter than in immature specimens.

Messrs. Newberry and Worthen have figured the supposed anterior dental plate belonging to this species,[1] but the specimen appears to be too strongly enrolled for coadaptation with the antero-lateral margin of the posterior dental plate, and the same criticism applies to the specimen referred by St. John and Worthen [2] to a corresponding position. There is no record of the two principal dental plates of this species ever having been found in natural association, and it will require the careful study of much additional material before we can be fully satisfied as to the characters of the anterior components of the dentition. It is to be noticed that the initial coiling is much less marked in the teeth of this species than in most forms of Deltodus and Sandalodus.

Formation and Locality. — Burlington, Keokuk, Warsaw, and St. Louis Groups; Iowa and Illinois.

Deltodus costatus (Newberry and Worthen).

1870. *Cochliodus costatus* Newberry and Worthen, Pal. Illinois, Vol. IV., p. 364, Pl. III., Fig. 10 (*non* Fig. 12).

1883. *Cochliodus costatus* St. John and Worthen, *Op. cit.*, Vol. VII., p. 167.

This species has not been previously reported from a higher horizon than the Burlington division of the Mississippian, but several examples from the Keokuk limestone are preserved in the United States National Museum and in the collections belonging to the State University of Iowa. Very similar teeth also occur in the Warsaw beds, and have been described as *Deltodus trilobus* by St. John and Worthen.[3] A tooth of the same general nature is also referred by the same authors to *D. occidentalis*, and is supposed by them to represent the anterior dental plate belonging to that species.[4] It is evident that the Warsaw forms last referred to are anterior dental plates, but attempts to correlate them with the posterior dental plates of other known forms are necessarily attended with great uncertainty.

Formation and Locality. — Burlington and Keokuk Groups; Iowa. (? Warsaw beds; Illinois.)

[1] Pal. Illinois, Vol. II., 1866, Pl. IX., Fig. 3.

[2] *Ibid.*, Vol. VII., 1883, Pl. IX., Fig. 10.

[3] *Ibid.*, Vol. VII., 1883, p. 148, Pl. IX., Fig. 8.

[4] Pal. Illinois, Vol. VII., 1883, Pl. IX., Fig. 10. (Warsaw limestone; Warsaw, Illinois.)

Deltodus contortus (St. John and Worthen).

(Plate 4, Figs. 37, 43.)

1883. *Taeniodus contortus* St. John and Worthen (*ex* L. G. de Koninck MS.), Pal. Illinois, Vol. VII., p. 76.

Type. — Posterior dental plate; Museum of Comparative Zoölogy.

The genus Taeniodus, with the type species of *T. contortus*, was held by its founders to be closely related to Psephodus, from which it was stated to be chiefly distinguished "by the pronounced differentiation of the coronal contour." Three species from the Mississippian series, besides the type, which is from the Lower Carboniferous of Belgium, were included under this genus by the original authors, but are distributed by A. S. Woodward in his Catalogue of Fossil Fishes between the genera Psephodus and Deltodus. We must express our complete concurrence with Dr. Woodward's views, and in order that others may judge of what the type species of Taeniodus is like, we here figure it for the first time, and would call attention to the close resemblance between it and the species of Deltodus illustrated in Plates IX. and X. of the seventh volume of the Illinois Palaeontology. These forms are interesting in that they show very distinctly the outlines of the individual teeth of which the large principal dental plates are composed.

Formation and Locality. — Lower Carboniferous limestone; Visé, Belgium.

POECILODUS M'Coy.

This genus is peculiar in having the two posterior series of teeth in each jaw fused into a single much enrolled plate, the coronal surface of which is marked by more or less distinct transverse ridges and furrows. St. John and Worthen supposed that plates of this character pertained solely to the upper jaw, and regarded the triangular plates commonly referred to the genus Deltoptychius as constituting the lower dentition of Poecilodus. This idea, however, is not shared by any subsequent writers, and there is abundant evidence to show that the dentition of each jaw of Poecilodus was transversely ribbed. Accordingly, the species described by St. John and Worthen as "*Poecilodus springeri*" and *P. wortheni*, in the seventh volume of the Illinois Palaeontology, are properly transferred to the genus Deltoptychius of Agassiz.

Poecilodus rugosus Newberry and Worthen.

1866. *Poecilodus rugosus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 94, Pl. VIII., Fig. 13.

1866. *Poecilodus ornatus* Newberry and Worthen, *Ibid.*, p. 95, Pl. VIII., Fig. 14.

1883. *Chitonodus rugosus* St. John and Worthen, *Op. cit.*, Vol. VII., p. 112, 119.

The specimens at the command of Newberry and Worthen at the time of their original description of this species were very fragmentary, and more perfect material in the hands of St. John and Worthen in 1883 enabled them to add to our knowledge of it. The latter authors were, however, mistaken in their correlation of Deltoptychius plates with the lower dentition of this species, as is proved by the occurrence in the Keokuk limestone of two forms of teeth determinable as the upper and lower dental plates of *P. rugosus*. The lower dental plates are more strongly enrolled than the upper, and have more strongly marked transverse ridges. Some specimens appear to indicate, also, that the fusion between the two parts corresponding to the anterior and posterior dental plates of Cochliodus is less intimate in the lower than in the upper dentition. The largest of the compound upper dental plates examined by the writer exhibits a length along the inner margin of 4.5 cm., and a width along the antero-lateral border of 2 cm.

Formation and Locality. — Keokuk limestone; Iowa and Illinois.

Poecilodus tribulis (St. John and Worthen).

1883. *Chitonodus tribulis* St. John and Worthen, Pal. Illinois, Vol. VII., p. 117, Pl. VII., Figs. 18–21.

A specimen belonging to the United States National Museum (Cat. No. 3496), and pertaining without doubt to this species, exhibits the characteristic fusion and transverse ribbing of Poecilodus, thus warranting its transfer to that genus. It appears not unlikely that the fragment described by Newberry and Worthen as *P. convolutus*[1] falls under the same specific limits as *P. tribulis*, but we are not prepared to unite the two under one head without the evidence of further material.

Formation and Locality. — Keokuk limestone; Iowa and Illinois.

ANTERO-LATERAL AND SYMPHYSIAL TEETH OF UNDETERMINED COCHLIODONTIDAE.

Under the provisional generic names of Helodus, Chomatodus, and Venustodus, a large number of species have been described from the Mississippian series which are held to represent the anterior dentition of various Cochliodonts, but in only a few instances are they capable of correlation with the principal grinding plates by which these forms are best known.

In the case of *Cochliodus latus* Leidy, this species has been definitely ascertained to possess at least one, and possibly more than one series of elongated Helodus-like teeth in advance of the large grinding plates in the upper and lower jaws, and also a symphysial series which has received the separate name of *Helodus coxanus* Newberry. Other teeth, which from their resemblance to "*Helodus coxanus*" may be referred to a corresponding position in the mouth, have been described under the names of *Chomatodus comptus* (*pars*) St. J. and

[1] Pal. Illinois, Vol. IV., 1870, p. 366, Pl. II., Fig. 9.

Worth., *Psephodus reticulatus* (*pars*) St. J. and Worth., *Helodus coniculus* Newb. and Worth., *H. triangularis*, and *H. acutus* Davis. To these must also be added the symmetrical tooth described below as *Helodus incisus*, sp. nov.

It has been shown by Traquair that the teeth named *Helodus planus* by Agassiz are certainly referable to *Psephodus magnus*, and Smith Woodward supposes that "most of the teeth from the Bristol Bonebed, named *Helodus laevissimus*, doubtless pertain to *Psephodus laevissimus*." The other teeth assigned to Helodus, however, are regarded by the same author as "probably common to one or more genera or species, and it is thus convenient, upon present evidence, to retain their provisional determinations." For the same reason, also, it is convenient to retain in a provisional sense most of the species which have been described under the name of Chomatodus.

Chomatodus inconstans St. John and Worthen.

(Plate 4, Figs. 32-34.)

1875. *Chomatodus inconstans* St. John and Worthen, Pal. Illinois, Vol. VI., p. 360, Pl. X., Figs. 5-14.

1875. *Chomatodus varsouviensis* St. John and Worthen, *Ibid.*, p. 363, Pl. X., Figs. 1-4.

1875. *Chomatodus chesterensis* St. John and Worthen, *Ibid.*, p. 363, Pl. X., Figs. 15-17.

This species occurs typically in the St. Louis limestone, but it was noted by the Illinois palaeontologists that very similar forms are found also in the underlying Warsaw beds, and in the Chester limestone above, to which the names *C. varsouviensis* and *C. chesterensis* were given respectively. There can be little impropriety in assigning to the same species teeth of the form shown in Plate 4, Figs. 32–34, which are from the Keokuk Group, thus indicating a continuous existence from this horizon onward throughout the Lower Carboniferous. The original of the accompanying figures belongs to the United States National Museum, and a second specimen is preserved in the Museum of Comparative Zoölogy.

Formation and Locality. — Keokuk to Chester Groups; Mississippi Valley.

Helodus incisus, sp. nov.

(Plate 5, Fig. 54.)

Type. — Isolated tooth; Museum of Comparative Zoölogy.

Teeth small, bilaterally symmetrical, more or less triangular in cross-section, the crown rising abruptly into a slightly recurved median eminence. Coronal surface uniformly smooth; posterior face strongly convex, anterior face very gently arched or almost plane, with a large Λ-shaped incision; faint ridges extend along the borders of the cavity on either side, and a third extends vertically from the angle where they meet to the coronal apex. Lateral expansions of crown short, slightly tumid at their extremities.

The tooth represented in the accompanying figures, which corresponds to the above description, is of the same general form as those known under the names of *Helodus coxanus* Newb., *H. triangularis*, and *H. acutus* Davis, all of which may be referred with little hesitation to the symphysial series of Cochliodont sharks. The slightly recurved apex in the species under discussion indicates that the series was feebly prehensile, and the triangular excavation to which the trivial title has reference, together with markings on the anterior face, show that the individual teeth of the series were very closely applied and slightly overrode one another. One other specimen, besides that shown in the figures, is preserved in the Cambridge collections, both having been obtained from the Subcarboniferous limestone of Salem, Indiana.

Formation and Locality. — Subcarboniferous; Salem, Indiana.

ICHTHYODORULITES PRESUMABLY REFERABLE TO COCHLIODONTIDAE.

The most plausible interpretation which has been given of the peculiar Ichthyodorulites known as Physonemus, Erismacanthus (including Gampsacanthus and Lecracanthus), Dipriacanthus, and certain forms of Oracanthus, is that they are head-spines corresponding to those already observed on either side of the head in the Permian Menaspis, and in one example of *Oracanthus armigerus* Traquair from the Calciferous sandstone of Eskdale, Dumfries. In our opinion the genus Stethacanthus should be placed in the same category with the above, and all these forms may be provisionally grouped with the Cochliodontidae. Various forms of Physonemus spines are arbitrarily distributed between Petalodus and Polyrhizodus by Jaekel,[1] but the evidence of actual association of parts, which is necessary for the confirmation of this conjecture, has not yet been forthcoming.

PHYSONEMUS M'Coy.

Very interesting stages of modification are displayed by the group of Physonemus-like spines throughout their existence in the Lower Carboniferous. The earliest and most primitive forms of Physonemus itself are found in the Kinderhook accompanied by small forms of Stethacanthus. The only known species, those described in the following pages, are of diminutive size, hook-shaped, and nearly destitute of surface ornamentation. Erismacanthus is also represented in the Kinderhook by two small comparatively unornamented species, and it is noteworthy that these have quite rudimentary anterior

[1] *Jaekel, O.*, Ueber die Organisation der Petalodonten (Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 285.

branches. The Burlington species of Physonemus and Stethacanthus display a marked increase in size, but they are feebly ornamented, and remain so throughout the stage represented by the Keokuk limestone. Stethacanthus seems to have attained its maximum size in the Keokuk Group, as Physonemus did in the Burlington, and a considerable falling off in this respect is true of both genera in the St. Louis division. The spines of Stethacanthus remain unornamented from the time of their first appearance in the Berea grit of Ohio until their extinction near the close of the Subcarboniferous, but those of Physonemus and Erismacanthus increase in complexity of ornamentation throughout the Mississippian series, ultimately displaying remarkable elaboration. An inspection of the forms illustrated in Plate XXII. of the sixth volume of the Illinois Palaeontology, and of the spines figured in the present contribution, will convince any one as to the correctness of these generalizations.

The spines in the typical species and in others resembling it are much laterally compressed, strongly arched or hook-shaped, with a broad base of insertion; the sides of the exserted portion are more or less ornamented with tuberculated longitudinal ridges, and small denticles are present upon the concave (posterior) border. This description applies to *P. arcuatus* M'Coy (the type species), *P. attenuatus* Davis, and *P. hamatus* (Agassiz), from the Carboniferous Limestone of Great Britain; and to the American forms described as *P. stellatus* Newberry, and *Drepanacanthus reversus* St. John and Worthen. Another group of spines which may be referred provisionally to the same genus is typified by such forms as the so-called *Drepanacanthus gemmatus* Newb. and Worth., *D. anceps* Newb. and Worth., *Xystracanthus acinaciformis* St. J. and Worth., *Physonemus gigas* Newb. and Worth., and the defences theoretically associated with the teeth of *Polyrhizodus rossicus* by A. Inostranzew [1] and O. Jaekel.[2] It is characteristic of the latter group of spines that they are forwardly curved, instead of backwardly, as in most Ichthyodorulites, a circumstance which appeared so anomalous to Newberry and Worthen as to warrant a generic separation from Physonemus. Transitional stages, however, showing the reversal of curvature from a posterior to an anterior direction, are to be observed in various species of Stethacanthus and Oracanthus, and for the present it seems best to extend the definition of Physonemus so as to include both groups. The two rod-like species from the Kinderhook limestone immediately to be described differ from all others in their more slender form and absence of ornamentation. They are undoubtedly to be interpreted as head-spines, a determination which is applicable to nearly all species of this genus.

[1] Travaux Soc. Nat. St. Petersb., Vol. XIX., 1888, pp. 1–18.
[2] Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 281, Fig. 5.

Physonemus hamus-piscatorius, sp. nov.

(Plate 5, Figs. 45, 46.)

Type. — Exserted portions of spines; Museum of Comparative Zoölogy.

Small hook-shaped spines, circular in cross-section, traversed by a small central pulp-cavity, and maintaining a nearly uniform diameter for the greater part of their length. External surface smooth or slightly roughened but not tuberculated, and no denticles present on either side. Inserted portion not observed.

The peculiar unciform spines shown in Plate 5, Figs. 45 and 46, from the Kinderhook limestone of Iowa, are the only examples at present known of this species. Both specimens are slightly abraded and afford no clue as to the nature of the inserted portion. The larger one is also fractured longitudinally for a considerable distance in such manner as to expose the tubular pulp-cavity, which in contrast to most species occupies a central position. The most striking differences displayed by the present form, however, are its circular cross-section and almost total absence of ornamentation. A small spine from the St. Louis limestone described by Messrs. St. John and Worthen as *Physonemus falcatus*, but which is probably the young of *P. arcuatus*, approaches the present form in its general outline, but differs notably in cross-section and other features. There is no reason to suppose that these spines are abnormally recurved, but on the contrary they may be looked upon as at once the most primitive, as they are also the earliest known representatives of Physonemus.

Formation and Locality. — Kinderhook limestone; Burlington, Iowa.

Physonemus pandatus, sp. nov.

(Plate 5, Fig. 44.)

Type. — Complete spine; Museum of Comparative Zoölogy.

Small, narrow, laterally compressed spines, the exserted portion erect and scarcely tapering for two thirds of its length, then becoming suddenly bent, more or less at right angles, but not decurved. External surface apparently unornamented, and denticles absent along the concave margin.

The unique example upon which this species is founded exhibits the whole of the exserted portion, and is broken off at the expanded base, the inference being that it was buried only to a slight extent in the integument. It is distinguished from the preceding species principally by its great lateral compression, and in its abrupt flexure without being curved downward toward the distal extremity. No traces are to be observed of superficial ornamentation, nor of denticles along the concave margin. This species, like the last, may be looked upon as a primitive forerunner of the group typified by *P. arcuatus*, immediately to be considered.

Formation and Locality. — Kinderhook limestone; Burlington, Iowa.

Physonemus arcuatus M'Coy.

(Text-figure 12.)

1848. *Physonemus arcuatus* F. M'Coy, Ann. Mag. Nat. Hist. (2), Vol. II., p. 117.
1855. *Physonemus arcuatus* F. M'Coy, Brit. Palaeoz. Foss., p. 638, Pl. III., Fig. 29.
1875. *Drepanacanthus reversus* St. John and Worthen, Pal. Illinois, Vol. VI., p. 456, Pl. XIX., Fig. 5 (*non* Fig. 6).
1883. *Physonemus arcuatus* J. W. Davis, Trans. Roy. Dublin Soc. (2), Vol. I., p. 367, Pl. XLVII., Fig. 8.
1883. *Physonemus falcatus* St. John and Worthen, Pal. Illinois, Vol. VII., p. 252, Pl. XXIV., Fig. 6.
1883. *Drepanacanthus reversus* St. John and Worthen, *Ibid.*, p. 253, Pl. XXIV., Fig. 5.
1890. *Physonemus stellatus* J. S. Newberry, Monogr. U. S. Geol. Surv., Vol. XVI., p. 200, Pl. XXI., Fig. 12.
1902. *Physonemus arcuatus* C. R. Eastman, Bull. Mus. Comp. Zoöl., Vol. XXXIX., p. 87.

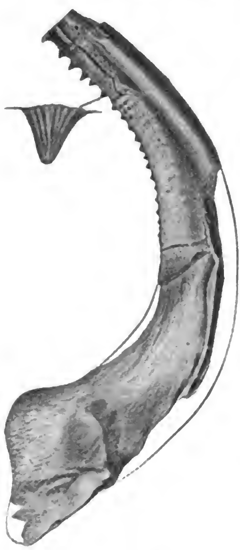


Fig. 12.

Physonemus arcuatus M'Coy. St. Louis limestone, Alton, Ill. Lateral aspect of spine, $\times \frac{1}{1}$, and single denticle, $\times \frac{7}{1}$.

All of the spines referable to this species which have been previously figured are imperfect in this respect, that the superficial ornamentation has been very largely denuded, and the denticles along the concave margin either worn or broken away, thus obscuring their true relations. Although the example shown in the adjoining Text-figure has been somewhat injured, its general outline is well displayed, and enough of the ornamentation remains to leave no doubt as to its identity with the type species of this genus. The double row of striated denticles bordering the concave margin is fully as prominent as in typical examples, although abrasion has reduced many of the tubercles in size. One of the latter is represented seven times the natural size in the figure to the left of the spine. Owing to the worn condition of the basal portion, it is not apparent to what depth the spine was inserted in the integument, but from some other specimens the writer has seen it is probable that it was not deeply implanted. There can be no question that the spines belonging to this species are homologous with the compressed posterior branch of Erismacanthus, and reasoning from analogy, it is natural to suppose that in the group typified by *P. arcuatus* the spines were curved in the normal direction, that is to say, posteriorly. In *P. gemmatus*, *P. stellatus*, and *P. gigas*, on the other hand, appearances are in favor of Newberry's conclusion that the usual curvature was reversed, the anterior margin being concave, and the posterior convex. Enlightenment as to how this reversal may have been accomplished is furnished by a study of the conditions in Stethacanthus and the Kinderhook specimens of *Oracanthus vetustus*.[1]

Formation and Locality. — St. Louis limestone; Illinois, Missouri, and Indiana. Lower Carboniferous Limestone ; Great Britain.

Physonemus gemmatus (Newberry and Worthen).

1866. *Drepanacanthus gemmatus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 123, Pl. XIII., Fig. 1.

1889. *Drepanacanthus gemmatus* J. S. Newberry, Monogr. U. S. Geol. Surv., Vol. XVI., p. 195.

A spine as perfect as the type of this species is preserved in the United States National Museum, and agrees with it in the form of the inserted portion. This, according to Newberry, affords proof that the spine was curved forwards with the concave margin toward the front, as in *P. gigas* and some other forms. We are inclined to think that Newberry was correct in this view, but mistaken in supposing that *P. arcuatus* was curved in the same direction. The propriety of including these two species in the same genus has already been suggested by Newberry and Smith Woodward.

Spines of the present species are not altogether uncommon in the Keokuk limestone, and good examples may be seen in the Cambridge and Iowa State Museums. Apparently the tubercles along the concave margin never attained a size sufficient to be called denticles. As in *P. stellatus* Newb. and Worth., the pulp-cavity is not central in position, but placed slightly nearer the convex margin.

Formation and Locality. — Keokuk limestone ; Iowa.

Physonemus stellatus (Newberry and Worthen).

1866. *Drepanacanthus (?) stellatus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 125, Pl. XII., Fig. 7.

1875. *Batacanthus stellatus* St. John and Worthen, *Ibid.*, Vol. VI., p. 470, Pl. XXI., Figs. 1–3.

Complete spines of this species have never been figured. Newberry and Worthen were acquainted with but a single fragment of the distal portion, but

[1] *Newberry, J. S.*, Trans. N. Y. Acad. Sci., Vol. XVI., 1897, p. 285, Pl. XXII., Fig 3.

noticed its resemblance in ornamentation to that of *P. gemmatus* from the same horizon. The specimens figured by St. John and Worthen are likewise from the distal third of the spine. The total length, as shown by one or two good examples in Iowa City, is really much longer than these authors supposed, and the breadth nearly equals that of *P. gemmatus*. The proportions of the two species are in fact very similar, the chief differences consisting in ornamental details, form of cross-section, and the greater development of tubercles along the concave border in the present species. In the distal portion of the spine these tubercles frequently appear as strong acuminate denticles. The pulp-cavity remains open for a short distance on the convex side near the base, and continues close to this side throughout the spine until near the tip. Like the preceding species, it is extremely probable that the spines of *P. stellatus* were curved forwards.

Formation and Locality. — Keokuk limestone ; Iowa and Illinois.

LIST OF NORTH AMERICAN SPECIES OF PHYSONEMUS.

Name of Species.	Kinderhook.	Burlington.	Keokuk.	St. Louis.	Chester.	Coal Measures.
1. *P. hamus-piscatorius* Eastman . . .	x	—	—	—	—	—
2. " *pandatus* Eastman	x	—	—	—	—	—
3. " *gigas* Newb. and Worth. . . .	—	x	—	—	—	—
4. " *gemmatus* (Newb. and Worth.) .	—	—	x	—	—	—
5. " *stellatus* (Newb. and Worth.) . .	—	—	x	—	—	—
6. " (?) *baculiformis* (St. J. and Worth.)	—	—	x	—	—	—
7. " (?) *necis* (St. J. and Worth.) . .	—	—	x	—	—	—
8. " *arcuatus* M'Coy	—	—	—	x	—	—
9. " *acinaciformis* (St. J. and Worth.)	—	—	—	—	—	x
10. " *anceps* (Newb. and Worth.) . .	—	—	—	—	—	x
11. " *asper* Eastman	—	—	—	—	—	x

ERISMACANTHUS M'Coy.

The two European and one American species of this genus that have been described are evidently very closely related to the type of Physonemus, but differ in that the spines are divaricated, the two branches extending in opposite directions in the same vertical plane. The imperfect Ichthyodorulites known as Gampsacanthus, Lecracanthus, and Dipriacanthus appear to be of the same general nature, and may be provisionally regarded as the dissociated anterior branches belonging to Erismacanthus. The Kinderhook species of this genus are small and exceedingly primitive as compared with the highly ornamented spines occurring in the St. Louis limestone, some of which attain the astonishing length of over 20 cm., and are provided with very large-sized denticles along the anterior arm. The forms included under this genus are referable to the head region with even greater certainty than those of Physonemus, and evidently occurred in pairs, whereas the latter would seem to have occupied a median position.

Erismacanthus barbatus, sp. nov.

(Plate 5, Fig. 47.)

Type. — Isolated and fragmentary spine; Museum of Comparative Zoölogy.

Spines small, very much laterally compressed, smooth or with faint longitudinal striae, and without denticles or tuberculations of any kind. Principal portion of spine gently arched, gradually tapering, and giving off two spiniform branches of unequal size from the convex margin.

This peculiar and in many respects primitive form of Erismacanthus is known by the solitary example shown of the natural size in the accompanying figure. It is excessively flattened, and consists of a gently arched portion corresponding to the denticulated posterior branch of other species, and of two rudimentary anterior branches, each with a thickened border and elevated ridge. A slight differentiation in the superficial ornament, which in later species becomes very pronounced, is already indicated in this early form, in that the main or posterior branch is feebly striated and the two anterior projections quite smooth.

Formation and Locality. — Kinderhook limestone; Burlington, Iowa.

Erismacanthus maccoyanus St. John and Worthen.

1875. *Erismacanthus maccoyanus* St. John and Worthen, Pal. Illinois, Vol. VI., p. 461, Pl. XXII., Figs. 1, 2, 4 (*non* Fig. 3).

This species has been known hitherto by only a few very diminutive spines from the St. Louis limestone, none of the specimens in the hands of Messrs. St. John and Worthen exceeding one inch in length. Whether all of the examples figured by these authors pertained to a single species was indeed questioned by them, on account of differences in the form and arrangement of the posterior denticles. Their views concerning the imperfect spine shown in Plate XXII., Fig. 3, of the seventh volume of the Illinois Palaeontology are thus expressed: "Whether the approximate arrangement of the denticles observed in the above specimen is indicative of specific distinctness from its associates we have not the means for determining; it is, however, probable that these closely arranged denticles gradually merge into the widely spaced and finally obtuse tubercles occurring near the base of the spine, as shown in fig. 1 a, and fig. 4 a."

Specimens that have come to light since the time of St. John and Worthen lead to the conclusion that the original of their Plate XXII., Fig. 3, which is peculiar in having "approximated denticles" along the posterior spine, is the young of a gigantic species recently described as *E. formosus*. It need only be remarked here that the additional material proves conclusively that the spines of Erismacanthus occurred as rights and lefts, and are presumably referable to the head-region.

The occurrence of *E. maccoyanus* in other formations than the St. Louis limestone has not been previously reported. A small branched spine, however, from the Kinderhook limestone of Le Grand, Iowa, belonging to the Museum of Comparative Zoölogy, appears referable to this species, notwithstanding its weathered condition. At all events, it agrees with the latter in size and form, but we are unfortunately left in doubt with regard to the superficial ornamentation.

Formation and Locality. — Kinderhook Limestone; Iowa. St. Louis Limestone; Missouri.

Erismacanthus formosus Eastman.

(Text-figure 13.)

1875. *Erismacanthus maccoyanus* (*errore*) St. John and Worthen, Pal. Illinois, Vol. VI., p. 461, Pl. XXII., Fig. 3.

1902. *Erismacanthus formosus* C. R. Eastman, Amer. Nat., Vol. XXXVI., p. 850, Text-fig. 1.

This, the largest known species of Erismacanthus, is interesting on account of its relatively gigantic size, being nearly seven times as large as *E. maccoyanus*,

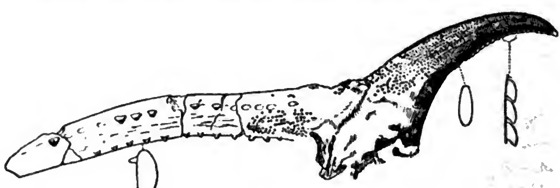


Fig. 13.

Erismacanthus formosus Eastm. St. Louis limestone, St. Louis, Mo. Outer face of cephalic spine belonging to the left side of the head, × ½.

which it accompanies in the same formation, and twice the size of *E. jonesi* M'Coy, the largest European species. It is also interesting in having paralleled the condition observed in certain Mesozoic Teleosts, such as Coccodus from the Lebanon Cretaceous, in which very similar head-spines are developed, and oriented in the same way, one on either side of the head. Appearances suggest that the long and stout anterior branch in the present form was for the most part buried in the integument, only the double row of robust conical denticles protruding, but the posterior spine was probably entirely exposed. The typical example of this species, shown in Text-figure 13 and now deposited in the Museum of Comparative Zoölogy, exhibits a total length of no less than 21.5 cm.

Formation and Locality. — St. Louis Limestone; Missouri.

STETHACANTHUS Newberry.

Definition (emend.). — Spines broad, much laterally compressed, triangular or falcate in outline, deeply inserted. The elongated basal portion thin-walled and occupied by a very large internal cavity which extends upward nearly to the apex; exserted portion terminated at one end by a strong, often tumid shoulder, and rising at the other by a gradual curve into an acuminate summit. Surface of spine having a rough, fibrous appearance and marked in the basal portion by coarse vascular impressions. Internal structure distinctly fibrous, owing to the fan-shaped radiation of numerous fine tubules from the apex toward the basal portion. Apex usually inclined posteriorly (*i. e.*, away from the tumid "shoulder"), but sometimes erect, or even slightly inclined forwards.

The peculiar class of dermal structures which are recognized under the name of Stethacanthus display quite uniform characters throughout their range from the Waverly to near the summit of the Mississippian series. They were regarded as pectoral fin-spines by Newberry,[1] who was under the mistaken impression that they were not bilaterally symmetrical, and was further misled by the fortuitous association on the same slab of a spine of *S. tumidus* with fin-rays of an Actinopterygian fish. There is no reason for supposing that they were situated elsewhere than in the median line of the body, either along the back or at the base of the head.

On considering the probable relationships of Stethacanthus, we are struck immediately with its resemblance to Physonemus, especially such forms as *P. gigas*, nor can a certain similarity be denied to the remarkable Kinderhook spine described by Newberry as *Oracanthus vetustus*, to which reference has already been made. In the latter form the base is much produced in an anterior direction, forming a most efficient anchorage in the soft parts for the exserted portion, and it is noteworthy that the tip of the exserted portion is slightly curved forwards. The same condition of things is developed to a somewhat lesser extent in *Physonemus gigas*, in which there is even an incipient "shoulder" at the base of the concave (anterior) margin. A more

[1] Monogr. U. S. Geol. Surv., Vol. XVI., 1889, p. 198.

advanced stage of modification than this is exemplified by the various species of Stethacanthus, the basal portion having become much elongated and the anterior "shoulder" very conspicuous. In the more primitive forms the summit projects but slightly above the line of insertion, and the concave margin is very gently curved. Gradually the summit becomes more strongly and abruptly elevated, finally assuming an erect or even recurved position, as in *S. altonensis* and some other species.

The anterior tumid portion or "shoulder" which terminates the exserted portion in the line of the body-wall in front, doubtless served as a buttress for strengthening the attachment of the spine in the soft parts and forms the initial portion of the cutwater. The depth to which the spine was inserted, or, in other words, the line of the body-wall, is denoted by the regular termination of the coarse vascular impressions which are limited to the basal portion. The latter is always more or less produced in advance of the anterior shoulder, and in some species it is also produced posteriorly beyond the point where the exserted portion enters the integument, as shown in Newberry's figure of *S. altonensis*.[1] This author's observation that "the base shows the outline of what seems to be a spheroidal head that fitted into the socket of an articulation" may be dismissed as having no foundation of fact, and probably arose from deceptive appearances.

The Devonian spines known as Acantholepis and Phlyctaenacanthus also exhibit a very large internal cavity, and appear to have been inserted in an essentially similar manner.

Stethacanthus altonensis (St. John and Worthen).

1875. *Physonemus altonensis* St. John and Worthen, Pal. Illinois, Vol. VI., p. 454, Pl. XIX., Figs. 1–3.

1875. *Drepanacanthus reversus* (*errore*) St. John and Worthen, *Ibid.*, p. 457, Pl. XIX., Fig. 6 a.

1889. *Stethacanthus altonensis* J. S. Newberry, Monogr. U. S. Geol. Surv., Vol. XVI., p. 198, Pl. XXIV.

This, the typical species, appears to be restricted to the St. Louis limestone, and in its larger size and nearly erect summit represents a more advanced stage of modification than the Burlington species. A specimen larger than any described belongs to the private collection of Dr. G. Hambach, in St. Louis, and has a total length of 24 cm., the basal portion being conspicuously produced beyond the limits of the exserted part both in front and behind. The walls have a uniform thickness of about 2 mm. throughout, except along the cutwater and posterior margin of the exserted portion. Newberry's statement that these spines exhibit a want of bilateral symmetry is clearly erroneous.

Formation and Locality. — St. Louis limestone; Illinois and Missouri.

[1] Monogr. U. S. Geol. Surv., Vol. XVI., 1889, Pl. XXIV.

Stethacanthus productus Newberry.

(Text-figure 14.)

1875. *Physonemus gigas* (*errore*) St. John and Worthen, Pal. Illinois, Vol. VI., Pl. XVII., Figs. 7–9.

1897. *Stethacanthus productus* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 291, Pl. XXIII., Figs. 2, 2.

1897. *Stethacanthus compressus* J. S. Newberry, *Ibid.*, p. 292, Pl. XXIII., Figs. 3, 4.

Type. — Imperfect spine; Museum of Chicago University.

The spines referred to this species are characterized by having the concave margin very gently curved, in consequence of which the apex is much inclined backwards. The smaller spines described by Newberry as *S. compressus* appear to be the young of the species under discussion, and it need scarcely be remarked that their correlation by this author with the pectoral and pelvic fins is entirely fanciful. Spines having the same form as *S. productus*, but of much smaller size, occur in the Kinderhook limestone of Iowa. The species described by Messrs. St. John and Worthen as *Physonemus depressus*, *P. carinatus*, and *P. gigas* (in part) are distinguished from one another and from *S. productus* in only minor details, and the types are extremely fragmentary. Nevertheless, it is convenient to regard the Kinderhook species as distinct from the Burlington, provisionally at least, and as representing the earliest and most primitive expressions of the genus. The Burlington species exhibit a marked increase in size, and in the next succeeding formation, the Keokuk, the maximum appears to have been attained by spines such as the one represented in the accompanying Text-figure.

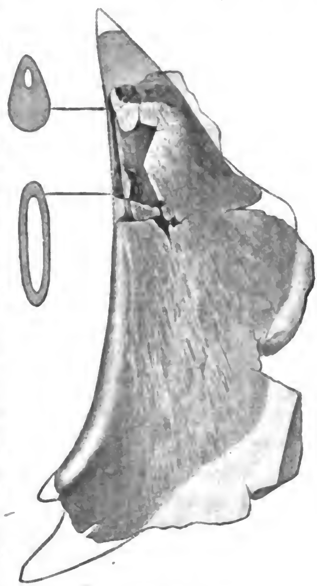


Fig. 14.

Stethacanthus productus Newb. Keokuk limestone, Keokuk, Iowa. Lateral aspect of spine, with cross-sections of summital portion, × ½ (approximately).

The original of this figure belongs to the United States National Museum at Washington, and was collected by Mr. L. A. Cox from a quarry in the Keokuk limestone on Cedar Street in the city of Keokuk. The spine was nearly perfect when found, but was injured in extricating it from the matrix. The shaded portion of the summit is now to be observed only in impression on the underlying slab, and the extreme tip is restored from a pencil sketch made by Mr. Cox according to his recollection. The dotted lines which are intended to show the anterior "shoulder" and basal projection as they occur in most species, are to be understood as conjectural, and a reliable index as to the elevation of the summital portion is therefore wanting. The width across the anterior shoulder at the point where it is broken off is no less than 3.7 cm., and it is in this region that the greatest thickness of the walls occurs. The thickness of the exserted portion is indicated by the two sections that are given, the upper one of which shows the approximation of the pulp-cavity toward the concave margin. The total length of the part preserved is 32 cm., and the total height 12 cm. Some hesitation is felt in referring this specimen to *S. productus*, but this course seems preferable to recognizing it as a distinct species.

Formation and Locality. — Burlington and Keokuk Groups; Iowa.

Stethacanthus depressus (St. John and Worthen).

(Text-figure 15.)

1875. *Physonemus depressus* St. John and Worthen, Pal. Illinois, Vol. VI., p. 452, Pl. XVIII., Fig. 3.

Only a few imperfect examples of this species were known to its authors, all of them under two inches in length, and recognized as distinct from other forms chiefly on account of the "shoulder" being broadly rounded from side to side, and the concave margin of the exserted portion being very gently curved. The complete outline of the spines belonging to this species is well shown in several specimens from the Kinderhook of Le Grand, Iowa, now in the collections of the United States National Museum at Washington. It is also well displayed in the original of Text-figure 15, which belongs presumably to the same species, and is from the Waverly sandstone of Marshall, Calhoun County, Michigan. Although the actual substance of this spine has

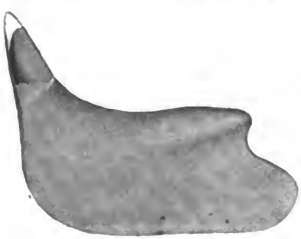


Fig. 15.

Stethacanthus depressus (St. J. and W.). Waverly sandstone, Marshall, Mich. Right lateral aspect of spine, × ½.

been considerably removed by chemical decomposition, yet where the surface is preserved it is seen to be covered with vascular impressions extending well up toward the superior margin, thus indicating that the spine was deeply implanted.

Formation and Locality. — Kinderhook; Iowa. Waverly sandstone; Michigan.

Stethacanthus erectus, sp. nov.

(Plate 3, Fig. 29.)

Type. — Imperfect spine; United States National Museum.

A species of about the same size as *S. depressus*, and differing from it in having the concave margin more abruptly curved, the exserted portion rising into a narrow and acuminate apex.

It is unfortunate that the specimen selected as the type of this species is not more perfectly preserved, as it seems to represent an intermediate stage in the modifications affecting the exserted portion of these peculiar spines, being in fact transitional between low forms like *S. compressus*, *S. carinatus*, *S. depressus*, etc., and those in which the apex is recurved, like *S. proclivus* and *S. altonensis*. The anterior shoulder and greater part of the basal portion of this unique specimen have been broken away, but it is probable that the complete outline would show that the base was produced for some distance posteriorly beyond the hinder wall of the summital portion, as in *S. altonensis* and some other species. The total height of the part preserved is 3 cm., thus indicating a species of about the same size as the preceding.

Formation and Locality. — Kinderhook limestone; Iowa.

CESTRACIONTIDAE.

HOMACANTHUS Agassiz.

This genus, which is evidently closely akin to Ctenacanthus, is thus defined by A. S. Woodward: "Dorsal fin-spines of small size, slender, more or less arched, laterally compressed, and gradually tapering distally; sides of exserted portion ornamented with few, large, smooth, widely spaced longitudinal ridges; a similar ridge also forming a large anterior keel; posterior face with a double series of large, downwardly curved denticles." The only American species that have been referred to Homacanthus have since been removed to other genera, but true representatives of this genus are apparently indicated by the spines described in the following paragraphs.

Homacanthus delicatulus, sp. nov.

(Plate 3, Fig. 28; Plate 5, Fig. 59.)

Type. — Isolated spine; Museum of Comparative Zoölogy, Cambridge.

Definition. — Spines very diminutive, erect, deeply inserted; base of exserted portion relatively broad, distal extremity acute, sides ornamented with not more than five or six straight longitudinal ridges.

The very minute and nearly perfect specimen which is here referred to Homacanthus might at first sight be assumed to belong to a young individual of Ctenacanthus, in which case it would correspond to the extreme tip of an adult spine. But even the distal extremity of all Ctenacanthus spines is distinctly tuberculated, and moreover, the costae appear too divergent, and the base of insertion too broad for this specimen to be regarded as a young form of Ctenacanthus. Besides, the Kinderhook species of Ctenacanthus are pretty well known, and there are none to which this small form corresponds even approximately, hence we may look upon it as belonging to Homacanthus.

The spine has a total length of about 1.8 cm., and maximum width of only 3 mm. The inserted portion is relatively very long and tapering, and the exserted portion has a narrow triangular form, the two portions being separated by a very oblique and prominently marked line of insertion. The lateral face is occupied by five smooth and continuous longitudinal costae, and two or three additional ones unite to form the anterior keel. Growth of the costae seems to have taken place by the coalescence of dentine tubercles formed just below the line of insertion, as shown in Plate **5**, Fig. 59. The absence of denticles along the posterior margin is to be accounted for by the effects of weathering or abrasion, or both. Some resemblance is to be noted between this spine and one of those figured by J. W. Davis as *H. microdus* from the Lower Carboniferous limestone of Armagh, Ireland (Trans. Roy. Dublin Soc. (2), Vol. I., 1883, Pl. XLVIII., Fig. 8.)

Formation and Locality. — Kinderhook limestone; Le Grand, Iowa.

Homacanthus acinaciformis, sp. nov.

(Plate 5, Fig. 58.)

Type. — Exserted portion of spine; Museum of Comparative Zoölogy.

Spines comparatively small, slender, gradually tapering, gently and uniformly arched; lateral surface with five or six smooth continuous longitudinal ridges; posterior denticles slender, rather widely spaced.

This species is noticed here principally for the sake of comparison with the preceding, and to illustrate the difference in degree of curvature pervading various spines included under the same genus. Indeed, if we may depend upon the determinations of J. W. Davis, spines belonging even to a single species of Homacanthus vary considerably in curvature.[1] The present form may also be compared with the spines referred by Davis and Newberry to the genus Hoplonchus, which is scarcely distinct from Homacanthus. The single American species assigned to Hoplonchus was originally described by Newberry as *Ctenacanthus parvulus*, and occurs in the Cleveland Shale (Upper Devonian) of Ohio.

Formation and Locality. — Chemung Group; Warren, Pennsylvania.

CTENACANTHUS Agassiz.

In a recent number of this Bulletin (Vol. XXXIX., No. 3), several species of Ctenacanthus were described from material belonging to the United States National Museum, and derived from the Kinderhook limestone of Iowa. Some of these spines had formed part of the Government display at the Omaha and other expositions, previous to their coming to Cambridge, and when placed in the hands of the writer for description the authorities at Washington were unable to furnish a record of the exact locality whence they were obtained. Since their description was published, however, information has been received from Mr. Charles Schuchert, who purchased the specimens, that the types of *C. longinodosus*, *C. lucasi*, *C. decussatus*, and *C. solidus*, together with the figured specimens of *C. spectabilis* and *C. venustus*, were collected by a Mr. McCabe from the Kinderhook quarries at Le Grand, near Marshalltown, in Marshall County, Iowa. A description of the formation as exposed in this vicinity will be found in Volume VII., pp. 221–226, of the Iowa Geological Survey Annual Reports (1896).

FRAGMENTS OF DERMAL ARMOR AND OTHER UNIDENTIFIED REMAINS.

Portions of calcified cartilage, detached tubercles, bosses, and dermal plates are of not infrequent occurrence in nearly all members of the Mississippian series, being particularly abundant in the Kinderhook and St. Louis limestones; and in a few instances nearly complete cartilaginous and osseous jaws have been brought to light, some of them dentigerous. None of these fragmentary remains are capable of satisfactory determination, although the more characteristic of them have received provisional designations, such as Petrodus, Stemmatias (*Stemmatodus* St. J. and Worth. *non* Heckel), Mazodus, etc. The wide range of form and ornamentation displayed by these bodies is remarkable, and it is evident that Carboniferous fishes possessed a much more varied external covering than their Devonian predecessors.

The survival of moribund Arthrodires during at least a part of the Kinderhook is witnessed by occasional dermal plates displaying the structure and tuberculation characteristic of this group. An examination of weathered and

[1] Trans. Roy. Dublin Soc. (2), Vol. I., p. 361, Pl. XLVIII., Figs. 7–9.

fractured specimens reveals the interesting fact that the growth of these plates was by secretion of new layers of bony tissue on both sides of the old, above and below, thus proving that the entire plate was covered by the integument. In no other way can we explain the presence of successive tuberculated layers underneath the external one, nor the regularly laminated structure of the plates as seen in cross-section. A number of undoubted Arthrodire plates from the Kinderhook near Burlington, Iowa, were collected many years ago by Messrs. Giles, Wachsmuth, and St. John, and are now preserved in the Cambridge Museum of Comparative Zoölogy.

As if in mimicry of the tuberculated covering of Arthrodires, rugose dermal plates were developed by their Elasmobranch contemporaries in the Kinderhook, probably through concrescence and fusion of shagreen granules; and their resemblance to the former is often so close that an examination of the microscopical structure is necessary to distinguish them. An example of such a plate, with symmetrical outlines and simulating the tuberculation of Arthrodires, is shown in Plate **5**, Fig. 50. The more common form of dermal tubercles,

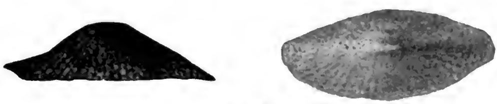


FIG. 16.

Dermal Plate of an undetermined Elasmobranch, in lateral and superior aspects, $\times \frac{1}{1}$. Kinderhook limestone, Burlington, Iowa.

however, is acutely or obtusely conical, as exemplified by Petrodus or by the spiniform bodies shown in Plate **5**, Figs. 56 and 57. Occasionally bodies are found having the form of elongated eminences, either symmetrical like that shown in Text-figure 16, or abruptly truncated on one side, as if they had been disposed in pairs, and recalling the dermal head plates of Myriacanthus and other Chimaeroids. Many of these tuberculated plates may be referred with considerable confidence to Chimaeroids, notwithstanding the fact that they are unaccompanied by dental plates. It is a remarkable circumstance that Chimaeroid jaws, which occur in great profusion in the Middle and Upper Devonian, are wholly unknown in rocks of Carboniferous age, and Dipnoans are conspicuously absent in the lower members of the same series. An explanation of their sudden disappearance at the close of the Devonian is possibly to be found in the change that took place from shallow to deep water conditions with the resultant migration of littoral forms.

In Text-figure 17 is shown of twice the natural size a peculiar fossil from one of the "fish-beds" near Burlington, Iowa, stratigraphically near the dividing line between Upper Devonian and typical Kinderhook. It is one of a score or more precisely similar bodies which were collected by St. John, Wachsmuth,

S. A. Miller, and others at this locality a number of years ago, and more recently Prof. J. A. Udden has collected further specimens of the same sort near Burlington. The nature of these bodies is entirely problematical, some of the best-known palaeontologists who have examined them being unable to express any decided opinion concerning them. Their finely laminated structure does not in the least indicate them to be of vertebrate origin, nor can they be satisfactorily classed with plant remains. The suggestion that they may have to do with Molluscan remains is as compatible as any with the internal structure, but we are at a loss to identify them with the usual hard parts, not even excepting the beaks of Nautiloids. Any attempt to homologize them with any known Crustacean structure is equally baffling. Owing to the not uncommon occurrence of these bodies in accompaniment with fish-remains in the Kinderhook, they are at least worthy of passing notice, and the accompanying figure is given in the hope that some clue may be found concerning their true nature.

FIG. 17.
Problematical fossil from the Kinderhook limestone of Burlington, Iowa, $\times \frac{3}{4}$.

EXPLANATION OF PLATES.

PLATE 1.

Fig. 1. *Campodus variabilis* (N. and W.). Missourian; Kansas and Nebraska. Supposed lower dentition, $\times \frac{1}{3}$. The symphysial series is photographed from an actual specimen obtained by Prof. E. H. Barbour from the Atchison shales of Cedar Creek, Cass County, Nebraska; the mandibular rami are photographed from a plaster cast of the specimen described by St. John and Worthen in the sixth volume of the Illinois Palaeontology. The original of the latter specimen was derived from the Missourian of Topeka, Kansas, and is now preserved in the private collection of O. H. St. John, at Raton, New Mexico.

Fig. 2. *Cestracion francisci* Girard. Recent; Pacific Ocean. Lower dentition, $\times \frac{1}{4}$. The cuspidate anterior and symphysial teeth are well shown by this specimen.

PLATE 2.

All figures are of the natural size, and photographed from the original specimens without retouching.

Fig. 3. *Cladodus occidentalis* Leidy. Atchison shales (Missourian); Table Rock, Nebraska. Outer coronal face of imperfect tooth, the lateral denticles and a portion of the root being broken away.

Fig. 4. *Cladodus knightianus* (Cope). Chase formation (Permo-Carboniferous); Blue Springs, Nebraska. Inner coronal face of imperfect specimen.

Fig. 5. *Peripristis semicircularis* (Newb. and Worth.). Atchison shales (Missourian); South Bend, Nebraska. Uninjured side of pathologic upper tooth.

Fig. 6. *Peripristis semicircularis* (Newb. and Worth.). Atchison shales (Missourian); Louisville, Cass County, Nebraska. Anterior aspect of upper dental plate, the root partially embedded in matrix.

Fig. 7. *Peripristis semicircularis* (Newb. and Worth.). Atchison shales (Missourian); South Bend, Cass County, Nebraska. Anterior aspect of upper dental crown, tilted slightly upward.

Fig. 8. *Cladodus occidentalis* Leidy. Neosho formation (Permo-Carboniferous); Roca, Lancaster County, Nebraska. Apical portion of crown, showing striated inner face.

Fig. 9. *Cladodus occidentalis* Leidy. Atchison shales (Missourian); Springfield, Sarpy County, Nebraska. Fragmentary basal portion viewed from the inner face, with lateral denticles preserved on one side, and showing prominent nutrient foramina of root.

Fig. 10. *Ctenoptychius occidentalis* (St. J. and Worth.). Atchison shales (Missourian); Richfield, Sarpy County, Nebraska. Outer coronal face of a weathered specimen, the root broken away.

Fig. 11. *Fissodus inaequalis* (St. J. and Worth.). Atchison shales (Missourian); Peru, Nemaha County, Nebraska. Inner coronal face of same specimen as shown in Plate **3**, Fig. 26.

Fig. 12. *Fissodus dentatus*, sp. nov. Missourian; Topeka, Kansas. Outer coronal face of tooth, the root broken away. Marks of contact with next older tooth are distinctly shown, serrations of lateral edges but faintly, in the photograph.

Fig. 13. *Janassa unguicula*, sp. nov. Atchison shales (Missourian); Cedar Creek, Cass County, Nebraska. Outer coronal face of tooth, the root broken away. The portion overlapped by next older tooth in front is indicated by the darker area at the base of crown.

Fig. 14. *Helodus rugosus* Newb. and Worth. Base of Cottonwood or summit of Atchison shales (Missourian); Table Rock, Pawnee County, Nebraska. Inner face of nearly perfect tooth.

Fig. 15. *Campodus variabilis* (Newb. and Worth.). Neosho formation (Permo-Carboniferous); Roca, Lancaster County, Nebraska. Coronal surface of supposed postero-lateral tooth, differing somewhat from any described by St. John and Worthen.

Fig. 16. *Campodus variabilis* (Newb. and Worth.). Atchison shales (Missourian); Louisville, Cass County, Nebraska. Coronal surface of a slightly asymmetrical tooth with feebly developed buttresses along the outer margin, and most nearly agreeing with the tooth figured by St. John and Worthen in Pl. VIII., Fig. **4**, of the sixth volume of the Illinois Palaeontology.

Fig. 17. *Petalodus alleghaniensis* Leidy. Atchison shales (Missourian); South Bend, Cass County, Nebraska. Anterior (outer) face of a broad-rooted and symmetrical tooth presumably situated in the azygous series in front. The opposite face of the same specimen is shown in Plate **3**, Fig. 27.

Fig. 18. *Petalodus alleghaniensis* Leidy. Base of Cottonwood or summit of Atchison shales (Missourian); Table Rock, Pawnee County, Nebraska. Posterior aspect of fragmentary specimen showing difference in form of root as compared with teeth occupying a position in the median azygous in front.

Fig. 19. *Deltodus angularis* Newb. and Worth. Permo-Carboniferous; Blue Springs, Gage County, Nebraska. Coronal surface of posterior dental plate referred to the right mandibular ramus.

Fig. 20. *Streblodus angustus*, sp. nov. Atchison shales (Missourian); South Bend, Cass County, Nebraska. Coronal surface of posterior dental plate referred to the left ramus of the upper jaw.

Fig. 21. *Janassa maxima*, sp. nov. Atchison shales (Missourian); Richfield, Sarpy County, Nebraska. Posterior (inner) coronal face of a fractured and

unsymmetrically worn specimen, presumably referable to one of the antero-lateral series of the upper jaw. The opposite face of the same specimen is shown in Pl. **3**, Fig. 24.

Fig. 22. *Ctenacanthus amblyxiphias* Cope. Atchison shales (Missourian); South Bend, Cass County, Nebraska. Left lateral aspect of fragmentary spine referable to the first dorsal fin.

Fig. 23. *Ctenacanthus amblyxiphias* Cope. Atchison shales (Missourian); Louisville, Cass County, Nebraska. Left lateral aspect of fragmentary spine showing characteristic ornamentation.

The original of Fig. 12 is preserved in the Museum of Comparative Zoölogy at Cambridge, the remainder in the Museum of Nebraska State University at Lincoln.

PLATE 3.

[All figures are of the natural size.]

Fig. 24. *Janassa maxima*, sp. nov. Anterior (outer) coronal aspect of same specimen as shown in Pl. **2**, Fig. 21.

Fig. 25. *Peripristis semicircularis* (N. and W.) Summit of Chester limestone; Montgomery Switch, Caldwell County, Ky. Lateral aspect of upper tooth, the root partially imbedded in matrix.

Fig. 26. *Fissodus inaequalis* (St. J. and Worth.) Lateral aspect of same specimen as shown in Pl. **2**, Fig. 11.

Fig. 27. *Petalodus alleghaniensis* Leidy. Posterior (inner) face of same specimen as shown in Pl. **2**, Fig. 17.

Fig. 28. *Homacanthus delicatulus*, sp. nov. Kinderhook limestone; Le Grand, Iowa. Spine referred to the first dorsal fin of a very small individual. An enlarged view of the same specimen is shown in Pl. **5**, Fig. 59.

Fig. 29. *Stethacanthus erectus*, sp. nov. Kinderhook limestone; Le Grand, Iowa. Left lateral aspect of fragmentary spine.

Fig. 30. *Sagenodus cristatus*, sp. nov. Coal Measures; Mazon Creek, Grundy County, Illinois. Oral surface of dental plate.

Fig. 31. *Elonichthys disjunctus*, sp. nov. Coal Measures; Mazon Creek, Grundy County, Illinois. Complete but somewhat distorted individual.

The originals of Figs. 25 and 28 are preserved in the Museum of Comparative Zoölogy at Cambridge; those of Figs. 24, 26, and 27, in the Museum of Nebraska State University; of Fig. 29 in the United States National Museum; and of Figs. 30 and 31 in the Museum of Yale University.

PLATE 4.

Figs. 32–34. *Chomatodus inconstans* Newb. and Worth. Keokuk limestone; Keokuk, Iowa. Coronal surface, anterior face, and transverse section of tooth, × $\frac{3}{4}$.

Figs. 35, 36. *Orodus intermedius*, sp. nov. Missourian; Weston, Platte County, Missouri. Anterior aspect and coronal surface of tooth, × $\frac{3}{4}$.

Fig. 37. *Deltodus contortus* (St. J. and Worth.). Lower Carboniferous limestone; Visé, Belgium. Posterior dental plate referred to the right ramus of the lower jaw, viewed from the postero-lateral margin, $\times \frac{1}{1}$.

Fig. 38. *Deltodus occidentalis* Newb. and Worth. Keokuk limestone; Keokuk, Iowa. Posterior dental plate referred to the right ramus of the lower jaw, $\times \frac{1}{1}$.

Fig. 39. *Phoebodus dens-neptuni*, sp. nov. Keokuk limestone; Keokuk, Iowa. Outer coronal face, $\times \frac{2}{1}$.

Figs. 40, 40 *a*. *Phoebodus knightianus*, sp. nov. Florence Flint, Chase formation (Permo-Carboniferous); Blue Springs, Gage County, Nebraska. Lateral and anterior aspects of imperfect crown, showing prominent projection of the base in the median line in front, $\times \frac{4}{1}$.

Fig. 41. *Deltodus spatulatus* Newb. and Worth. Keokuk limestone; Keokuk, Iowa. Posterior dental plate referred to the right ramus of the lower jaw.

Fig. 42. *Deltodus spatulatus* Newb. and Worth. Burlington limestone; Burlington, Iowa. Posterior dental plate referred to the right ramus of the lower jaw, $\times \frac{1}{1}$.

Fig. 43. *Deltodus contortus* (St. J. and Worth.). Coronal surface of same specimen as shown in Fig. 37, $\times \frac{1}{1}$.

The originals of Figs. 35–43 are preserved in the Museum of Comparative Zoölogy; the single tooth represented in Figs. 32–34 belongs to the United States National Museum.

PLATE 5.

Fig. 44. *Physonemus pandatus*, sp. nov. Kinderhook limestone; Burlington, Iowa. Lateral aspect of spine, $\times \frac{1}{1}$.

Fig. 45. *Physonemus hamus-piscatorius*, sp. nov. Kinderhook limestone; Burlington, Iowa. Lateral aspect and cross-section of exserted portion of spine, $\times \frac{1}{1}$.

Fig. 46. *Physonemus hamus-piscatorius*, sp. nov. Kinderhook limestone; Burlington, Iowa. Exserted portion of spine in lateral aspect, with rugose distal extremity, and a portion of the substance removed by fracture, exposing tubular pulp-cavity, $\times \frac{1}{1}$. A tooth of *Helodus biformis* N. and W. is imbedded in the same block of limestone in immediate juxtaposition to this spine.

Fig. 47. *Erismacanthus barbatus*, sp. nov. Kinderhook limestone; Burlington, Iowa. Fragmentary spine with rudimentary anterior branches, $\times \frac{1}{1}$.

Fig. 48. *Coelacanthus exiguus* Eastm. Coal Measures; Mazon Creek, Grundy County, Illinois. Complete individual of average size, $\times \frac{1}{1}$.

Fig. 49. *Elonichthys perpennatus* Eastm. Coal Measures; Mazon Creek, Grundy County, Illinois. Complete fish, probably of a young individual, with downwardly flexed caudal fin, fine fulcra on the pectorals, and impressions of the axis showing through the delicate squamation, $\times \frac{3}{2}$.

Fig. 50. Tuberculated dermal plate belonging to an undetermined Elasmobranch. Kinderhook limestone; Burlington, Iowa, $\times \frac{1}{1}$.

Fig. 51. *Platysomus circularis* Newb. and Worth. Coal Measures; Mazon Creek, Grundy County, Illinois. Complete fish with well-preserved fins and squamation, $\times \frac{2}{3}$.

Fig. 52. *Cheirodus orbicularis* (Newb. and Worth.). Coal Measures; Mazon Creek, Grundy County, Illinois. Complete fish with well-preserved fins and dorsal and ventral peaks, $\times \frac{2}{3}$.

Fig. 53. *Deltodus occidentalis* Newb. and Worth. (var. *D. latior* Newb. and Worth.). Keokuk limestone; Keokuk, Iowa. Posterior dental plate referred to right ramus of the lower jaw.

Figs. 54, 54 *a*, 54 *b*. *Helodus incisus*, sp. nov. Mississippian; Salem, Indiana. Supposed symphysial tooth corresponding to the form known as "*Helodus coxanus*" Newb. Seen in anterior, posterior, and lateral aspects, $\times \frac{1}{1}$.

Fig. 55. *Deltodus spatulatus* Newb. and Worth. Burlington limestone; Burlington, Iowa. Anterior dental plate referred to the left ramus of the lower jaw, and described by Messrs. St. John and Worthen as a distinct species ("*D. convolutus*"), $\times \frac{1}{1}$.

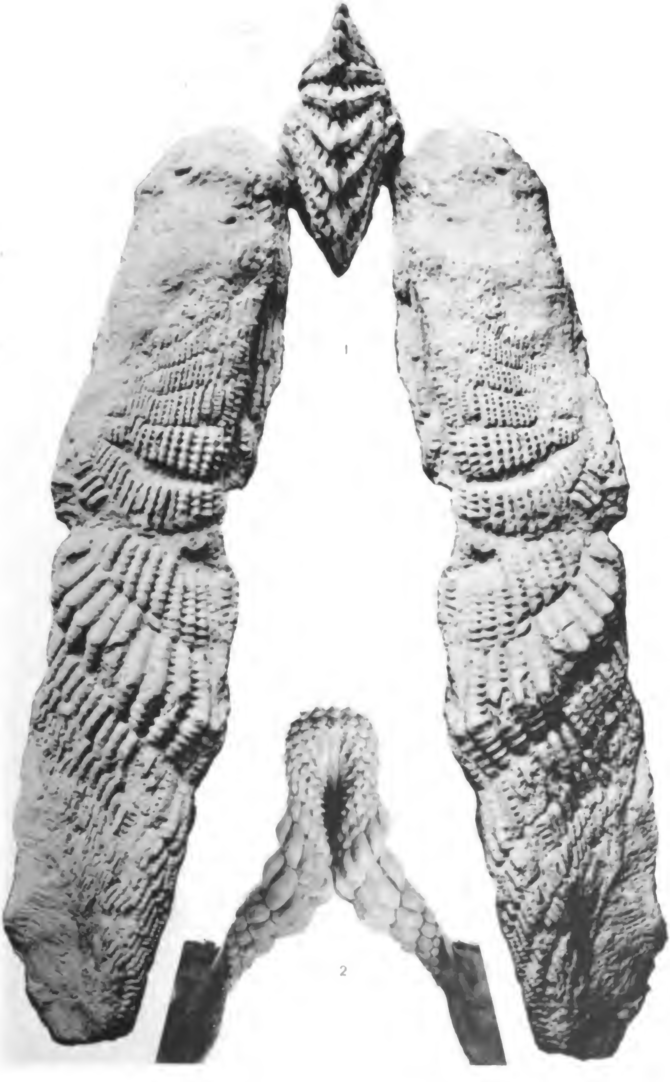
Fig. 56, 56 *a*. Tuberculated dermal plate of an undetermined Elasmobranch. Kinderhook limestone; Burlington, Iowa. The unsymmetrical cross-section near the base is shown in Fig. 56 *a*, $\times \frac{1}{1}$.

Fig. 57. A spiniform dermal tubercle of the same nature as that shown in Fig. 56, the external surface much corroded and displaying the fibrous internal structure, $\times \frac{1}{1}$.

Fig. 58. *Homacanthus acinaciformis*, sp. nov. Chemung Group; Warren, Pennsylvania. Lateral aspect of spine lacking inserted portion, $\times \frac{1}{1}$.

Fig. 59. *Homacanthus delicatulus*, sp. nov. Kinderhook limestone; Le Grand, Iowa. The same spine as shown in Plate 3, Fig. 28, four times enlarged.

The originals of Figures 48, 51, and 52 are preserved in the Peabody Museum of Yale University; the remainder in the Museum of Comparative Zoölogy.



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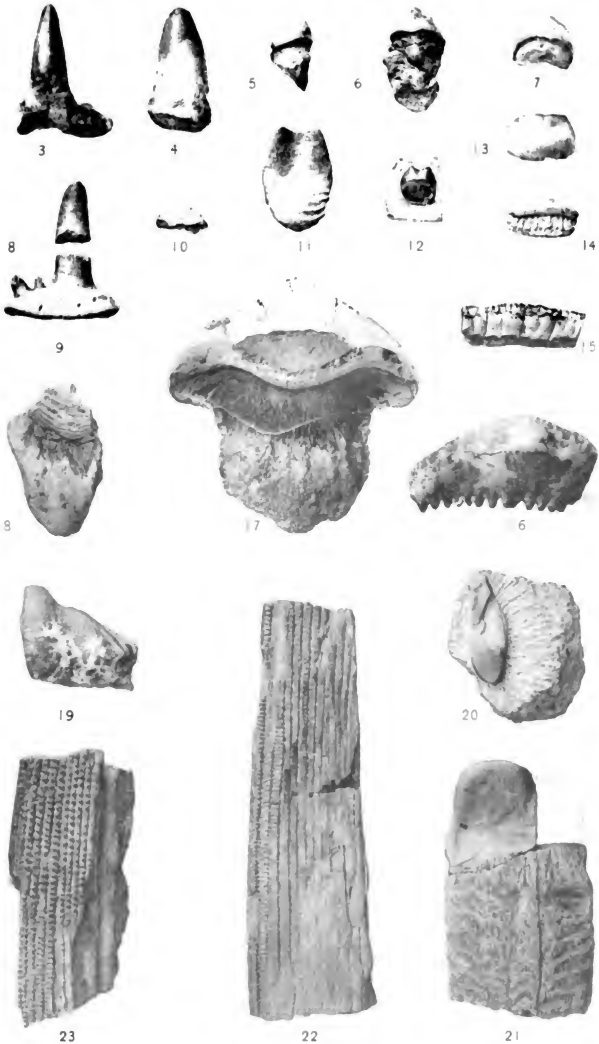

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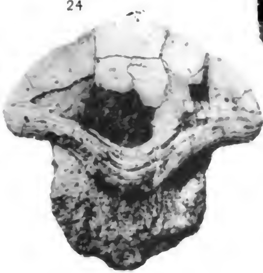
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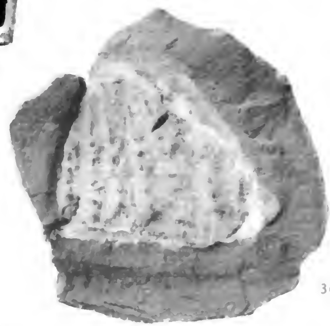
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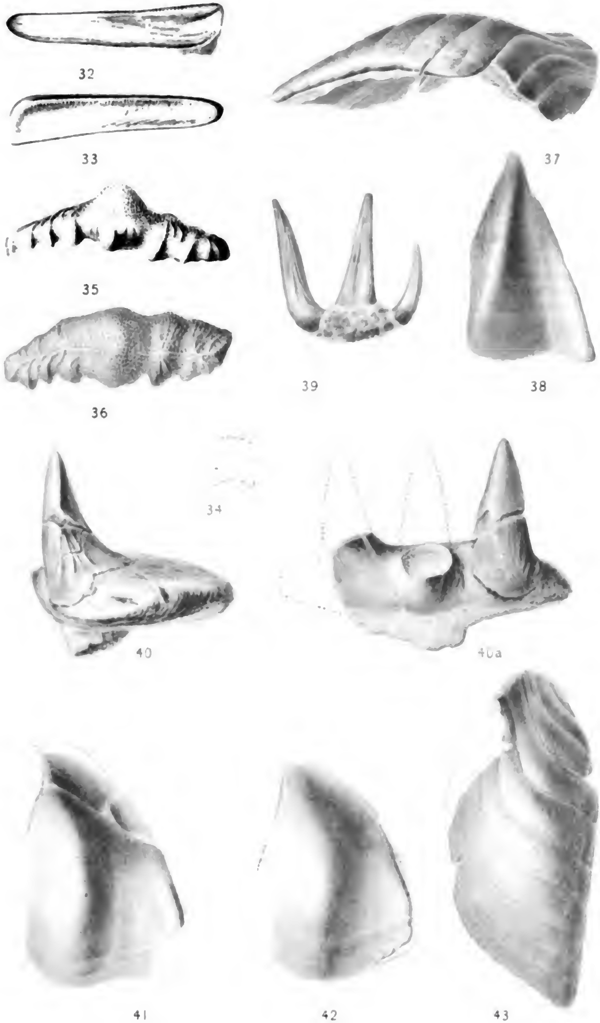

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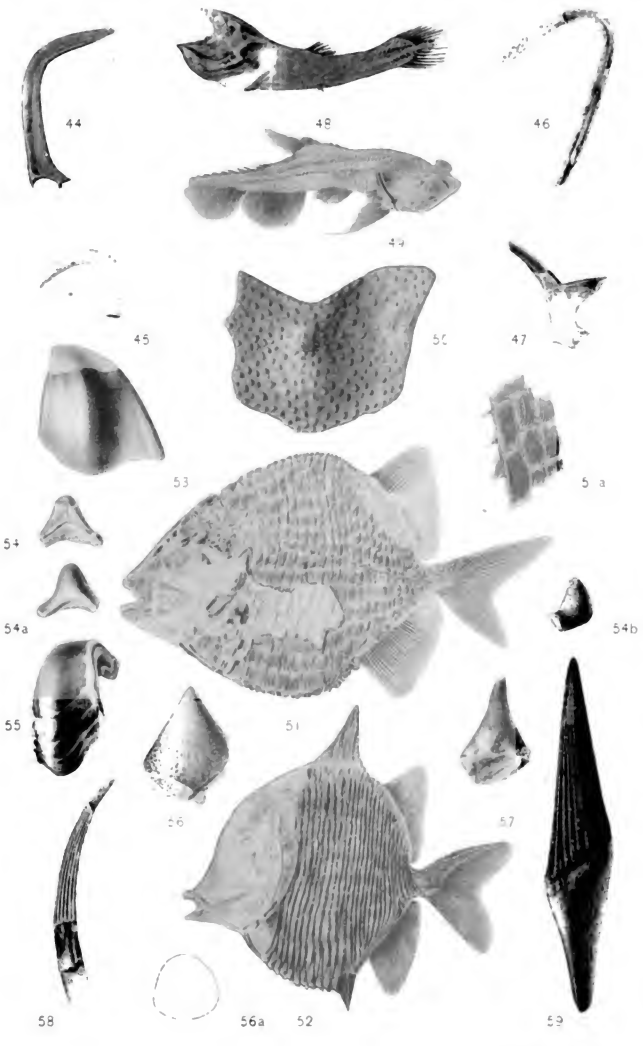
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SOME FISHES FROM AUSTRALASIA.

BY SAMUEL GARMAN.

WITH FIVE PLATES.

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No. 8. — *Some Fishes from Australasia.* By SAMUEL GARMAN.

THE notes and descriptions subjoined are based on specimens taken by Mr. Alexander Agassiz and members of his party on his recent expeditions to the Islands and Coral Reefs of Fiji and to the Great Barrier Reefs of Eastern Australia. Owing to the fact that no special attempts were made to collect fishes, the collection is not very large. Such individuals as came in the way while collecting invertebrates were preserved. Among them are some that belong to species ranging throughout Polynesia, to China and the Red Sea; there are others that probably have been identified with species tolerably well known on account of close affinities, but which, because of differences lost sight of under former arrangement, are now given descriptions and names, and still others that have escaped notice hitherto. Only species inhabiting the shoals around the islands or the reefs or the upper waters of the open sea are represented.

Epinephelus merra BLOCH.

D. 11 + 17; A. 3 + 9; V. 6; P. 16; Ll. 91.

Taken on the reef at Suva, Fiji Islands. The markings vary some from those of the published figure. Certain of the spots are darker than the others and their arrangement is such as to form transverse bands, of which one crosses the nape and descends to the operculum, another passes downward, including the second to the fifth spinous rays of the dorsal, across the flank, a third goes down from the hindmost three of the same spines and a fourth crosses from the middle rays of the soft portion of this fin to the anal. Three or four larger and blacker spots are to be seen on the basal portions of the pectoral rays.

Apogon nubilus, sp. nov.

Plate 1, Fig. 1.

Br. r. 7; D. 7 + 10; A. 2 + 8; V. 6; P. 12; Ll. 26; Ltr. 2 + 6.

Form short, stout, compressed; depth nearly one-third of total length. Head deep, short, in length equal to depth of body; crown depressed, nearly flat. Snout blunt, short, half as long as the eye. Eye large, two-sevenths as long as head. Mouth large, rising obliquely forward; maxillary widened backward, bearing a low ridge, reaching below the middle of the eye. Teeth very small, in narrow villiform bands on the jaws, in a single doubly curved series on the vomer, and in groups of a few each on the ends of the palatines. The space between the dorsals is nearly equal to the length of the snout. The anterior dorsal spine is short, the second is not quite as long as the third, and the last is equal to the spine of the second dorsal, to the second spine of the anal, or to the length of the eye. Scales broad, minutely spinose on and near the hind margin, those of the lateral line with a rounded ridge and separated from the dorsals by the width of a single scale or from the vertebral line of the caudal pedicel by two scales. Caudal notch shallow, fin appearing truncate when spread.

Color brownish, head darker, darker on crown and back; with seven silvery bands across the flanks below the dorsals and a blackish spot on the lateral line about three scales from its end, forward from the bases of the caudal rays. A dark streak passes from below the middle of the eye backward and down to the hinder angle of the preoperculum.

Allied to *A. monochrous* of Bleeker, but readily distinguished by the markings. From *A. lineatus* of Schlegel it differs in the larger eye, shorter maxillary, the notch in the caudal, the shapes of the fins, and the caudal spot.

Taken at Suva, Fiji Islands.

Apogon crassiceps, sp. nov.

D. 6, 1 + 9; A. 2 + 9; V. 6; P. 13; Ll. 23; Ltr. 9.

To some extent the shape of this species resembles that of *A. nubilus*, but the lower jaw is shorter, the caudal region is longer, and the foremost portions of the fins are longer and more angular. The outline from the snout to the dorsal is slightly arched at the crown of the head. Head large, thick, equal in length to the depth of the body, little less than one-third of the total, convex on the occiput. Snout blunt, three-fourths as long as the eye. Eye large, more than one-third of the head. Mouth large, cleft rising forward, jaws about equally prominent, maxillary wider backward and reaching to or beyond a vertical from the hind margin of the eye. Teeth small, equal, in villiform bands on jaws, vomer, and palatines. A weak opercular spine. Space between dorsal fins short, one-third the length of the snout. First ray of spinous dorsal short, second ray stronger and longer than any of the other rays; hinder spines decreasing rapidly in length and strength. Spine of soft dorsal slender, three-fifths of the length of the first soft ray in dorsal or anal, one-third shorter than longest ray of first dorsal. As the lengths of the soft rays in anal and soft dorsal decrease rapidly backward, these fins have an angular appearance. Caudal notch deep, lobes rather sharp. Preopercle with a ridge near the finely serrated posterior margin. Scales large, ctenoid, about twenty-three in a longitudinal and about nine in a transverse series; two rows above the lateral line.

Color whitish (in life reddish or yellowish), dark on the crown and along the back, with puncticulations of dark along the middle of the side in the hinder half of the caudal region and on the outer extremity of the caudal fin; fins light.

From Suva Reef, Viti Levu, Fiji Islands.

Scorpaena erinacea, sp. nov.

Plate 1, Fig. 2.

Br. r. 7; D. 13 + 9; A. 3 + 6; V. 6; P. 19; Ll. 43.

Body stout, depth equal length of head or two-sevenths of the total length, back subregularly and strongly curved from snout to end of dorsal fin. Cephalic ridges and spines strong and sharp; no depressed space on the crown; top of head covered by scales; orbital ridges high; interorbital space narrow, deep. Snout shorter than the eye, less than one-fourth of the head, blunt. Eye large, little less than one-third of the head. Mouth large; maxillary reaching to a vertical from the hind border of the orbit, hind margin strongly curved; lower jaw little longer. Anterior nostril tubular, inner edge with a broadened flap bearing numerous filaments. Prominent filaments appear at and behind the spines of the head and the dorsal fin. Scales of the lateral line with a ridge and a filament. Scales ctenoid, large on the body, smaller on the top and sides of the head. Pectorals about as long as the head, rays scaly on the basal half. Posterior edge of caudal very convex.

Color brown (reddish in life), mottled and blotched with darker; a dark blotch on the operculum; a transverse band, more or less completely divided into two, at the bases of the caudal rays; a similar band across the flank from soft dorsal to anal; a series of four to six spots at each side of the dorsum extends on the dorsal fin; caudal, anal, and dorsal with irregular narrow transverse bands or transverse series of spots or blotches of brown; pectorals and ventrals with numerous small spots of brown, basal portions dark; breast and belly spotted; flanks with numerous more or less indistinct and irregular spots and blotches. The spots on the fins are separated by areas of lighter ground color. There are less distinct indications of bands below and behind the eye and behind the operculum; these may be described as a narrow darker band from the interorbital space through the eye to the branchiostegal rays, another parallel with it at the hind edge of the orbit and a third passing in front of the dorsal to the base of the pectoral. There are several indistinct spots along the lower edge of the gill cover and some small spots of white on the lateral line.

Suva Reef, Viti Levu, Fiji Islands.

Pterois zebra C. V.

D. 12 + 9 ; A. 3 + 6 ; V. 6 ; P. 17 ; Ll. 50 ; Ltr. 8 + 20.

Of this specimen the dermal flaps and filaments are especially prominent. The flap at the inner side of each anterior nostril is long and pointed ; there are two barbel-like flaps, and a symphysial flap, above the edge of the intermaxillary ; below the orbit above the angle of the mouth above the maxillary there is a broad leaf-like flap; at the lower edge of the preopercle there are two broad fan-shaped narrow based ones; and above the orbit on each side there is a prominent flap with fringes.

Suva, Fiji Islands.

Synanceia verrucosa Bl. Schn.

On a large and apparently very old specimen of this species taken at Thuvu, Fiji Islands, the extremities of the rays on the pectoral, ventral, and anal fins are encased in hardened callosities. The skin is thick and so rough and warty over body and fins, and the coloration is such, that the fish bears a close resemblance to a piece of coral rock.

Caranx parasitus, sp. nov.[1]

Br. r. 7; D. 8 + 23–24 ; A. 2 + 20; Ll. 43 (on the straight portion).

Several individuals of this Caranx at Cairns, Barrier Reef, Australia, "from among the tentacles of Rhizostome Medusa, *Crambessa mosaica* Haeck." In shape they approach *C. hippos*. The lower outline is rather more arched than the upper. Height of body equal length of head, or two-sevenths of the total length. Eye large, near one-third of the head. Teeth on the jaws in a single series. Lateral line strongly curved anteriorly, straight from below the fifth ray of the soft dorsal, keeled plates rather small.

Body and head yellow ; back and top of head tinted with olive; chest and lower part of abdomen white; a large black opercular spot; anterior dorsal blackish; margin of second dorsal and margins and ends of caudal black.

From the formulae this species appears closely allied to *Caranx calla* C. V. It differs in coloration.

Caranx regularis, sp. nov.

Br. r. 7 ; D. 8 + 23 ; A. 2 + 20; P. 21 ; Ll. 35 (in the straight portion).

The upper outline of this species differs little from the lower in curvature. The body is greatly compressed, the depth being more than one-third of the total length. Head as deep as long, one-fourth of the total; snout longer than

[1] Recorded as *Trichiurus declivis* Jenyns, Bull. Mus. Comp. Zoöl., XXXII., p. 18.

the eye, blunt; mouth medium, maxillary hardly reaching a vertical from the front border of the orbit; teeth small in narrow bands on jaws and vomer and in a single series on the palatines; eye large, one-fourth of the head. The curve of the lateral line is moderately strong and regular until it reaches the straight portion, near a vertical from the sixth ray of the second dorsal; there are thirty-seven broad, sharply keeled plates in the posterior section. Fins of medium size; longest ray of either spinous dorsal, soft dorsal or anal less than twice the orbital length; excepting half a dozen of the anterior soft ones, the rays of dorsals and anal are short. Breast naked.

Color olivaceous to grayish yellow on the back, lighter below; back crossed by five broad vertical bands of black, descending to about the middle of the flank, the posterior one of which continues back on the top of the caudal pedicel to a dark area on the bases of the caudal rays. The first band crosses the spinous dorsal, which is black; the second passes through the space between the two dorsals; the third lies below the highest portion of the second dorsal, and the fourth and fifth lie below the short rays of the same fin. The fins, except the first dorsal, are light colored with dusky margins. There is a small and comparatively faint spot at the upper angle of the operculum. No band through the eye.

Captured at Suva, Fiji Islands.

Percis tetracanthus La C.

Br. r. 6; D. 3 + 20; A. 17; V. 5; P. 18; Ll. 63; Ltr. 8 + 14.

The orbits are black; there is a large spot of black below the base of each pectoral and a black spot in the anterior part of the lower half of the caudal.

Suva Reef, Fiji Islands.

Gobius atriclypeus, sp. nov.

Plate 2, Fig. 1.

D. 6 + 12; A. 12; Ll. 25; Ltr. 10.

Body compressed, elongate, depth one-seventh and caudal fin near two-sevenths of the total length. Head about one-fifth of the total; interorbital space very narrow. Snout short, two-thirds as long as the eye, pointed as seen from the side, subtruncate as seen from above. Mouth wide, oblique, rising steeply forward; maxillary subtending anterior one-third of eye. Teeth small, in bands, with one or two canines at each side above and below. Eyes large, more than one-third of the head, prominent, very close together on the top of the head, longer than the snout. Occiput covered with scales, to the ridges behind the orbits. Scales large, ctenoid with minute teeth. Fin rays flexible, elongate. First dorsal spine above the axil of the pectoral; depth of first dorsal less than that of the body; height of second dorsal greater than that of the first. Caudal long pointed, ending in a filament. Anal origin below that of soft dorsal. Pectorals long, ending in a filament above the fourth or fifth ray of the anal.

Color light brownish, fins darker; ventrals black; a series of small spots of brown along the middle of the flank from the cheek to a black spot on the bases of the caudal rays.

Secured in the Bay of Moala, Fiji Islands, on the east side, in twenty-five fathoms depth.

Gobius waitii, sp. nov.

Plate 3, Fig. 3.

D. 6 + 10; A. 10; Ll. 27; Ltr. 10.

Body short and thick, depth nearly one-fourth of the total length. Head short and broad, five-seventeenths of the total length. Snout short, little longer than the eye. Mouth medium, nearly vertical; canine teeth rather small. Eye one-fourth as long as the head. Bases of dorsal fins united by membranes. Caudal of moderate length, pointed. Ventrals short, disk broader than long, subcircular. Scales large and ctenoid on the body, hidden on the head by dermal growths that give the appearance of being roughened by short sharp points or flaps of skin.

Color yellowish, slightly browned toward the back, lighter below head and abdomen and near the edges of the fins. Caudal apparently with an edging of dark. No spots or bands.

From Cairns, Great Barrier Reef, Australia.

Specific name given in honor of the Australian ichthyologist, Edgar R. Waite, F. L. S.

Gobiodon atrangulatus, sp. nov.

Plate 2, Fig. 2.

D. 7 + 11; A. 10; P. 19.

Body much compressed, deeper anteriorly, tapering backward; width two-fifths of the depth; depth more than one-third of the total length. Head three-fifths as long as deep, narrow above the orbits, swollen on the cheeks, strongly arched from mouth to nape. Snout short, blunt, rounded, as long as the orbit. Eye less than one-fourth of the length of the head. Nostrils with raised margins. Gill openings as wide as the bases of the pectorals and situated immediately in front of them. Dorsal origin above the base of the pectoral. First dorsal short, little if any more than half as high as the second; second larger and higher than the first, from which it is not separated, angles rounded or blunt. Anal rounded, deeper than first dorsal. Caudal deep, hind margin convex. Pectorals broad, subround. Ventrals twice as long as the eye.

Color brownish, probably light red or yellow in life. The only spot or mark appears to be a small black one on the upper angle of the gill cover. This spot resembles that in the same position on *G. citrinus* and may indicate kinship, but there are no traces of the characteristic vertical streaks of that species, and the dorsals are not separated.

Found off Nairai, Fiji Islands.

Gobioides totoyensis, sp. nov.

Plate 3, Figs. 1 and 2.

Br. r. 4; D. 6 + 45; A. 45; V. 5; P. 7 + 6.

Body compressed, depth one-eighth and body cavity one-third of the total length. A fold below the abdomen behind the ventrals, somewhat like the tropeic fold in certain sharks. Head short, about one-sixth of the entire length, narrow above, apparently with a swollen tract or cushion on the forehead, from occiput to mouth. Snout short, upper jaws shorter, lower jaws stronger, chin protruding. Mouth medium, cleft rising obliquely forward; maxillary reaching to a point below the eye; lips thick; teeth small, in villiform bands, a very small canine at each side above and below. Eyes minute. No barbels. Gill openings wider than the bases of the pectorals, upper angle of each opening forward of the middle of the base of the fin. Dorsal, anal, and caudal continuous; the skin enveloping them not especially thick. Anterior dorsal spine above the mid-length of the pectoral fin; first six rays of the fin lower and closer together than the following rays, but not separated from the balance of the fin by a space. Caudal elongate, one-seventh of the total, pointed, united by membrane with dorsal and anal. Anal origin below the eleventh ray of the dorsal. Ventrals short, longer than the pectorals, subtruncate, parallel, close together, with inner edges joined together and to the body, appearing externally as if containing but four rays each. Pectorals not extending as far backward as the ventrals, twice as wide as long, with protruding rays, in two sections of which the lower — six rays — is truncate, and the upper, of eight or nine rays, is longer and pointed. Lateral line distinct on the head, in a median tube anteriorly on the flank and backward to the scaly portion, below the thirty-fifth ray of the dorsal, where in a series of larger scales it has the ordinary appearance on bony fishes. Scales cycloid, appearing to be absent from the anterior three-fifths of the body; backward they are comparatively large.

Color uniform brownish white, probably yellowish or flesh color in life.

Taken in Totoya, Fiji Islands, outside of Kini-kini and inside of thirty fathoms depth.

Periophthalmus schlosseri Pall.; Bl. Schn.

D. 8 + 13; A. 11.

The descriptions of *P. schlosseri* do not mention several transverse bands which cross the back, passing down and obliquely forward on the flanks of these specimens. The first dorsal is dark brown and has a light edging. Second dorsal, pectorals, and caudal have transverse series of small elongate spots of brown. The ventral disk is similar to that figured by Pallas on his type, from Amboyna. On immature specimens of an inch and a quarter in length the disk is as perfect as on the large ones.

Suva, Fiji Islands; Keppel Bay, Australia.

Periophthalmus koelreuteri Pall.; C. V.

D. 7–13 + 12–13; A. 12–13; Ll. 64–78; Ltr. 18.

The fishes placed here were captured on the Great Barrier Reef, Australia. Apparently of a single species, they exhibit a wide range in variation. The rays in the first dorsal number seven in the smallest individuals, and eight, nine, ten, and fourteen on larger ones. The largest have a black band in the upper half of the same fin; it is represented by a black spot on the hinder rays in the smallest of the lot. There are seven or eight scales between the dorsals on the larger and nearly twice as many on the smallest specimens. Commonly there are seven or eight bands of brown separated by spaces of lighter color about equal in width, crossing the back and passing down and forward on the flank. The ventrals are separate at all ages.

Blennius canescens, sp. nov.

Plate 4, Fig. 1.

D. 10 + 16; A. 17; V. 2; P. 15.

Outlines in some degree resembling those of *B. maoricus* Kner, 1867, but the head is more pointed and less convex in the frontal region, and the filament above the orbits is shaped differently. Body compressed, robust, depth equal to length of head and contained three and two-thirds times in the length without the caudal. Head short, blunt-pointed at the snout, with a low arch above the orbits. Snout short, half as long as the eye. Mouth medium, cleft rising slightly forward, maxillary reaching below the anterior one-fourth of the eye. A canine on each of the lower jaws and two smaller ones near the symphysis on each upper jaw. Eye large, less than three times in the length of the head. A short slender filament above each eye (not shown in figure); no filament and no crest on the nape; a short nasal filament on each side. Dorsal notched, spinous portion originating above the base of the pectoral; rays in spinous portion shorter. Pectorals broad, rounded on hind margin. Caudal slightly notched, little shorter than the head. Lateral line extending to a point below the first spine of the second dorsal.

Color uniform light brownish, white or yellow; a brown band across the occiput from eye to eye; a brown spot above the orbits.

From the eastern entrance of Mbengha Passage, Fiji Islands.

Petroscirtes obliquus, sp. nov.

Plate 4, Fig. 3.

D. 12 + 19; A. 22; V. 2; P. 13.

Moderately elongate, compressed, depth nearly one-sixth and length of head nearly one-fifth of the total length. Head deeper than wide; cheeks swollen; crown rising somewhat high on the interorbital space longitudinally and rather flattened transversely; without either crest or filaments. Snout rounded, blunt, half as long as the eye. Margins of nostrils prominent. Mouth comparatively narrow, maxillary reaching little below the forward part of the orbit. Teeth strong, fixed, in a single series, with very strong canines behind each series; those of the lower jaws a little stronger than those of the upper series. Eye large, one-third as long as the head, very prominent above the forehead. Gill openings small, above the bases of the pectorals. Rays of soft dorsal longer than the spinous rays. First dorsal ray above the gill opening. First ray of the anal below the eleventh ray of the dorsal. Caudal subtruncate, free from dorsal and anal. Pectorals medium, pointed, lower rays averaging longer than the upper. Ventrals slender, of two rays which are separate for half their length, inner ray one-third longer than the outer. Lateral line marked by three or four pores, the hindmost of which is below the third ray of the dorsal.

Color light olivaceous brown; a black spot behind the eye and several transverse bands on the lower half of the head; a series of bars of brown on the flanks, the anterior of which incline forward, the posterior, backward; a couple of spots at the base of the tail; a series of small spots near the bases of the dorsal; first dorsal clouded or spotted; anal fin with spots along its base and with a darker margin; ventrals, white; pectorals, dusky; abdominal cavity showing dark through its walls.

Locality, Suva, Fiji Islands.

Salarias sertatus, sp. nov.

Plate 4, Fig. 2.

D. 15 + 23; A. 2 + 27; V. 3 (4); P. 14.

The outlines of body and fins have a remote resemblance to those of *S. periophthalmus;* the most prominent differences appear in the length of the caudal, in the depth of the notch between the dorsals, and in the frontal filaments. Body elongate, slender, depth or length of head one-seventh of the total length. Head short, as wide as deep, very blunt, nearly vertical in front of the eyes. A low crest on the nape. Eyes large, prominent, one-fourth as long as the head. Mouth wide, inferior. Teeth very numerous, small, movable, in single series; no canines. Gill membranes continuous and free across the throat, extending higher than the bases of the pectorals. A short, flattened, fringed postorbital tentacle; no other filaments. Dorsal origin above bases of pectorals; dorsal notch very shallow; extremities of rays protruding beyond the membrane. Anal origin below the tenth ray of the dorsal, rays of the fin exserted; the membranes descend from ray to ray, forming a serrated margin. Pectorals broad, nearly straight on the upper border, convex on the hinder edge, broadly rounded on the lower margin. Caudal one-fifth of the total length, medium rays longest, separated from dorsal and anal. The rays protrude on all the fins.

Color uniform dark olivaceous, lighter on the belly, anal, ventrals, and pectorals; each of the fins except the caudal with a whitish edge. Very young with more of light color on lower surfaces and fins.

Found "hopping about on the rocks above high tide" on Solo Island, North Astrolabe Reef, Fiji Islands.

Salarias fasciatus Bl.; C. V.

D. 12 + 17; A. 21; V. 2 (3); P. 14.

In all likelihood this fish belongs to Bloch's species, though the figure given by that author neglects the fringed filaments on the nape, the nasal filaments, and the short barbel below each angle of the mouth. The bands on our fish are less numerous and extend but halfway up on the dorsal; thence they are broken into small spots.

Near Suva, Fiji Islands.

Dascyllus aruanus Linn.; C. V.

D. 12 + 12; A. 12; V. 6; P. 16; Ll. 25; Ltr. 3 + 10.
Suva, Fiji Islands.

Glyphidodon uniocellatus Q. G.

D. 13 + 13; A. 2 + 12; V. 6; P. 18; Ll. 26 (17 pores); Ltr. 2 + 9.
Suva, Fiji Islands.

Hemirhamphus laticeps Günt.

D. 15; A. 15.

On the middle of the flank of very young specimens of this fish there is a longitudinal streak of brown, becoming wider and more noticeable from the ventrals to the base of the caudal. Another streak of brown extends along the median line of the ventral surface. On the middle of the back there is a vertebral line of very small dots with a line of similar dots immediately at each side of it, and at each side of the three there is a line of much larger dots. The beak is black and the black extends back on each side of the head to below the eye. The upper jaw and the orbits are black. The crown is dotted and puncticulate with black.

Suva, Fiji Islands.

Zenarchopterus maculosus, sp. nov.

Plate 5, Fig. 4.

D. 11; A. 10; Ll. 44; Ltr. 8.

Length of head two and two-fifths times in the total length, or two and one-sixth times in the length to the caudal. Length of lower jaws, forward of intermaxillary, one-fourth of the total without the caudal. Intermaxillaries as wide as the eye, wider than long, rounded in front. A tubular nostril. Eye large, one-eighth of the entire head, little less than supraorbital width, equal width of upper jaws. Beak with a dermal expansion below and a prolongation at the tip. Dorsal in the hindmost one-fourth of the total length; first ray forward of that of the anal; base less than two-thirds as long as the head. Base of anal little more than half the length of that of the dorsal; first ray of the fin below second ray of dorsal. First ray of ventral at hindmost one-third of the total; fin not reaching the anal. Bases of ventrals little nearer to bases of pectorals than to base of caudal. Caudal rounded.

Black of jaws extending on the side of the face to below the eye. A broad band of blackish from opercle to base of caudal on the middle of the flank, inferiorly fading to round spots in each of which there is a central dot of light color, white or bluish. Back and belly lighter, dotted with brown. Dorsal blackish toward its margins.

Suva, Fiji Islands.

Gymnothorax nebulosus Ahl; Bl. Schn.

Suva Reef, Fiji Islands.

Gymnothorax pictus Ahl; Bl. Schn.

Suva Reef; Nukulau Island, Fiji Islands.

Syngnathus conspicillatus Jen.

Plate 5, Fig. 2.

Three miles south of Suva lightship.

Ichthyocampus sp.

Plate 5, Fig. 3.

Six miles east of Suva.

Balistes aculeatus Linn.

Suva Reef, Fiji Islands.

Alutera armata, sp. nov.

Plate 5, Fig. 1.

D. 2 + 44; A. 46; P. 14; C. 14.

Elongate, slender, much compressed, deep in front of dorsal and anal; greatest depth equal length of caudal, little less than one-third of the total length. Length of head hardly one-fourth of the total. Snout blunt, slightly concave in upper outline as seen from the side, two and one-third times as long as the eye. Eye large, three and one-half times in the head. Gill opening as wide as the eye, oblique, below the orbit, above the base of the pectoral. Lower edge of breast and belly thin, blade-like, very convex. Squamation villiform. Both dorsal spines above the orbit; anterior strong, long, more than twice the length of the eye, with four series of sharp hooks directed toward the base, the anterior two of which are close together; second spine very small, close to the first. Second dorsal and anal opposed, latter originating by several rays farther forward. Caudal pedicel slender; fin long, pencil-shaped, wide. Pelvic bone rather rigid; pelvic spine continuous with the bone, immovable. Pectorals small, broad, and short, as long as the eye, longer in their upper halves.

Light yellowish or olivaceous brown, darker on head and back; with transverse blotches of brown on forehead, first spine, and back; with irregular subvertical series of brown blotches on flanks and tail, arranged in pairs, the first pair being below the space between first dorsal and second, the second pair below the anterior twelve or fourteen rays of the soft dorsal, and the third farther back toward the end of the fin, while the fourth is on the caudal pedicel. The spots on the caudal are comparatively large; the tip of the fin is dark.

Suva, Fiji Islands.

EXPLANATION OF PLATES.

PLATE 1.

Fig. 1. *Apogon nubilus*, sp. nov.
Fig. 2. *Scorpaena erinacea*, sp. nov.

PLATE 2.

Fig. 1. *Gobius atriclypeus*, sp. nov.
Fig. 2. *Gobiodon atrangulatus*, sp. nov.

PLATE 3.

Fig. 1. *Gobioides totoyensis*, sp. nov.
Fig. 2. *G. totoyensis*, lower surface.
Fig. 3. *Gobius waitii*, sp. nov.

PLATE 4.

Fig. 1. *Blennius canescens*, sp. nov.
Fig. 2. *Salarias sertatus*, sp. nov.
Fig. 3. *Petroscirtes obliquus*, sp. nov.

PLATE 5.

Fig. 1. *Alutera armata*, sp. nov.
Fig. 2. *Syngnathus conspicillatus* Jen.
Fig. 3. *Ichthyocampus* sp.
Fig. 4. *Zenarchopterus maculosus*, sp. nov.

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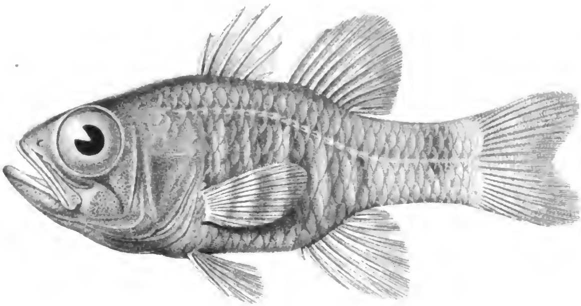

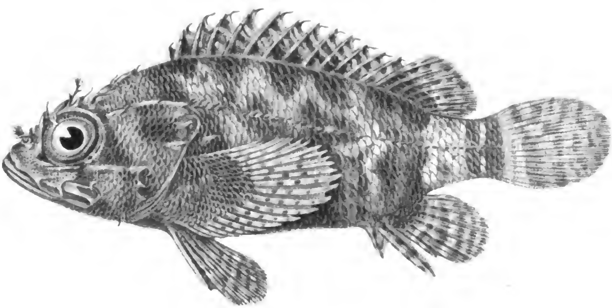

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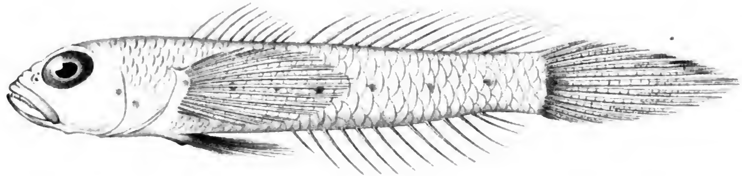

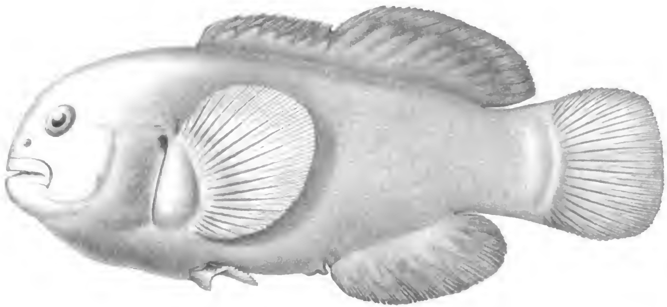

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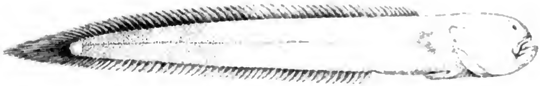

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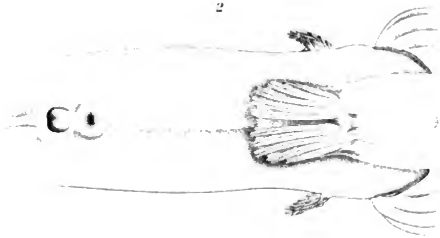

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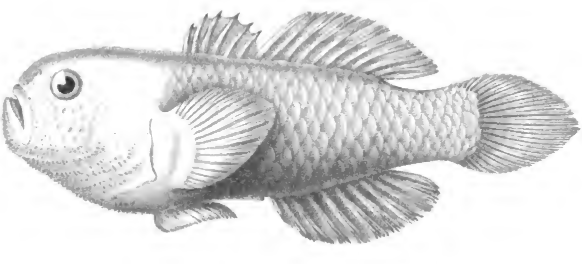

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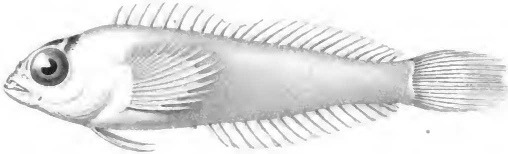

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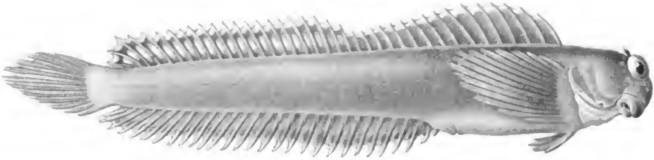

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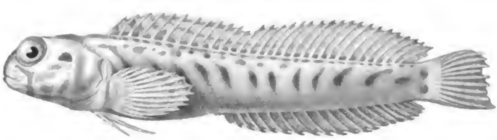

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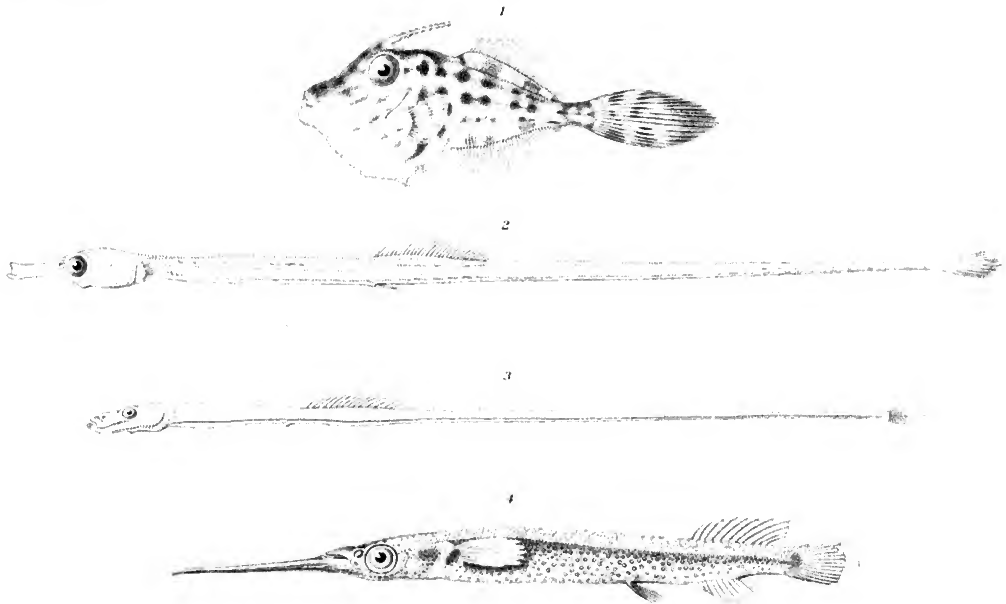

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MEDUSAE FROM THE MALDIVE ISLANDS.

By Henry B. Bigelow.

With Nine Plates.

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No. 9.—*Medusae from the Maldive Islands.* By HENRY B. BIGELOW.

THE Medusae described in the following pages were taken during the exploring trip of the steamer "Amra" to the Maldive islands, carried out by Mr. Alexander Agassiz during the months of December, 1901, and January, 1902. I accompanied the expedition as assistant to Mr. Agassiz, and during the cruise the capture and preservation of the Medusae fell to my special care. The original drawings for the figures accompanying this article were made on the spot, from life.

I wish to express my gratitude to Mr. Agassiz for his kindness in giving me the opportunity to visit the islands; and also for his assistance in the preparation of the manuscript and illustrations for this paper.

The Maldive islands, which comprise thirteen main atolls and several smaller ones, occupy the greater part of a submarine plateau the area of which is about thirty-five thousand square miles. The islands themselves extend from 8° north to 1° south latitude; and the long axis of the group nearly coincides with the 73d meridian of east longitude. The peculiarly open condition of the larger atolls, especially of the more northern ones, which has already been described by Mr. Agassiz (Amer. Journ. Science, March, 1901), allows free access to the water on all sides, and strong currents sweep through the passages and lagoons in all directions. This, as is noted later, has had a considerable influence on the distribution of the Medusae. During our visit, which lasted from December 25, 1901, until January 22, 1902, we made surface hauls at seventeen stations, in eleven atolls, and intermediate hauls at three stations, off the easterly faces of Kolumadulu, Haddummati, and Suvadiva atolls. The surface towing was done with a small net, at our nightly anchorages within the lagoons. The strong currents, which ran almost continuously, made it possible for us to tow when the ship was at anchor, by merely lowering the net overboard and letting the water run through it.

The intermediate hauls were all made with large open nets, at depths from near the surface to one hundred fathoms. We took Medusae at every station, and in every haul; but the inside hauls were uniformly much more productive than those made at sea. This is probably in large measure due to the fact that the former were always made at about nine o'clock in the evening, an hour which seems particularly favorable for Medusae to come to the surface, and when the water was always very calm. The surface of the ocean itself was usually rather barren during the daytime; but on one occasion, on January 19, while we were sounding to the eastward of Guradu island, we found it very rich, taking Physalia, Porpita, Cestus, Aurelia, Oceania, Aglaura, and swarms of Copepods, Amphipods, Pteropods, and Heteropods.

The small number of our outside hauls makes it impossible to draw any comparison, between the Medusa fauna of the lagoons and of the open sea, more comprehensive than the following correlation between the open character of the atolls, with their free circulation of water, and the fact that there was no Trachomedusa which we took outside, and did not take commonly inside as well. Of the nineteen species of Hydromedusae which we collected, eleven were Leptolinae, and eight Trachylinae, a proportion of Trachyline forms which at first sight seems large, considering that by far the greater number of hauls were made in shallow, enclosed waters within the lagoons. The explanation for this condition again is found in the free circulation through the atolls, which is constantly sweeping the adjacent surface water of the ocean through them to an unusual degree.

We took in all sixteen genera of Hydromedusae, two of Scyphomedusae, three of Siphonophorae and four of Ctenophorae, making a total of twenty-five genera, represented by twenty-nine species: of these one genus and fifteen species are new: nine species are already known, while four, represented each by a single specimen, were too fragmentary for determination. The number of Siphonophores, when compared with similar collections from other tropical waters, is surprisingly small. That so few of the species known to occur off the coast of Ceylon (Haeckel, Siphonophorae of the "Challenger" Expedition) exist also in the Maldives is very improbable, and the smallness of our catch must be attributed to some other cause.

The distribution of the fifteen new species is as follows: of the eleven Leptolinae, all, with one possible exception (Dipurena), are new; of the eight Trachylinae four are new; of the two Discomedusae, one; and of the four Ctenophorae, all, with one possible exception, are new. All of the Siphonophores belong to well-known and widely distributed species. The geographical occurrence of the nine known species is shown in the following table. The mark 0 signifies that the species is represented by an exceedingly closely allied, if not identical form.

Species.	Atlantic.	Pacific.	Indian.
? Dipurena fragilis Mayer.	0		+
Messonema coerulescens Brandt.		+	+
Rhopalonema typicum Maas.	0	+	+
Aglaura prismatica Maas.	0	+	+
Aeginella dissonema Haeckel.	+	+	+
Nausithoe punctata Kölliker.	+	0	+
Porpita lutkeana Brandt.			+
Diphyopsis appendiculata Agass. & [Mayer	0	+	+
Physalia megalista Péron.	0		+

Considered from the standpoint of morphology, many of the new species are of interest, since they differ from their nearest allies in important structural characters. Such species are: Euphysa tetrabrachia, the only Euphysa possessing three prominent short tentacles; Timoides agassizii, the only Leptomedusa possessing blind centripetal canals in the bell wall; Aurelia maldivensis, the only Aurelia with long pendent mouth parts. Taken as a whole, the new species uniformly show a very decided separation from their near allies in the Atlantic and Pacific, and there is only one, Dipurena fragilis, which seems to be a geographic race of a well-known Atlantic form.

The Maldive islands form in every respect a typical tropical coral reef region, and a comparison of their Medusa fauna with that of similar regions in the Pacific and Atlantic is therefore of interest. Such other regions, of which the Medusae have been studied, by A. Agassiz and A. G. Mayer (see Mayer, Bull. Mus. Comp. Zoöl., vol. 37, and Agassiz and Mayer, Bull. Mus. Comp. Zoöl., vol. 32, no. 9), are the Fiji Islands and the Tortugas.

Taking first Fiji, we find the following conditions. The two areas have in common the following thirteen genera: Aeginella, Aglaura, Bougainvillia, Eirene, Eutimeta, Gonionemus, Liriope, Oceania, Aurelia, Nausithoe, Beroe, Diphyopsis, and Physalia. But of these thirteen only four are represented by the same species. These are Aeginella dissonema Haeckel, Aglaura prismatica Maas, Nausithoe punctata Kölliker, and Diphyopsis appendiculata Agassiz and Mayer. These are all forms of very general distribution, and all either occur in the Atlantic or are represented there by exceedingly close allies. Of the thirteen genera common to both regions, not one is peculiarly Pacific; and the most characteristic Pacific forms, the Rhizostomae, were not found at all in the Maldives. This is of interest in view of their common occurrence in the Red Sea and the Persian Gulf, and off Zanzibar. (Vanhöffen, E. Untersuch. über Semaeostome und Rhizostome Medusen. Bibl. Zoöl., bd. 1, heft 3, 51; and Chun, Beitrag. Zum. Kentniss öst Afric. Medusen, etc., Mittheil. Nat. Mus. Hamburg, jahrg. 13, p. 5, 1896.)

If we turn now to the Tortugas in the tropical Atlantic (Mayer, A. G., Bull. Mus. Comp. Zoöl., vol. 37, no. 2), we find they have in common with the Maldives the following fifteen genera: Aeginella, Aglaura, Bougainvillia, Dipurena, Gonionemus, Liriope, Oceania, Aurelia, Nausithoe, Diphyopsis, Physalia, Porpita, Beroe, Bolina, and Ocyroe. Of these, however, four only are represented by identical or even by exceedingly closely allied forms; these are Dipurena fragilis, Aeginella dissonema Haeckel, Aglaura hemistoma Haeckel, and Nausithoe punctata Kölliker.

A similar comparison with the Mediterranean shows twenty-one genera in common, but only two species, Aeginella dissonema Haeckel and Nausithoe punctata Kölliker; with two more, Rhopalonema typicum Maas and Aglaura prismatica Maas, represented by very closely allied forms. With the exception of the new genus Timoides, every genus found in the Maldives is well known in the Atlantic, and the following typically Atlantic genera, not recorded from the Pacific, were taken in the Maldives. These are Berenice, Turritopsis, and Ocyroe.

General Conclusions.

The Medusa fauna of the Maldives shows a very general resemblance to that of the Tortugas in the Atlantic and Fiji in the Pacific, as shown by the large number of genera which they possess in common. But the fact that very few of these genera are represented by identical species, and, still more important, that all such identical species are forms well known to be of very wide distribution throughout the tropical waters of the globe, is good evidence that this Maldive fauna has no recent relationship to either of the other areas. The general resemblance of the three is to be explained on the ground that they all belong to the characteristic "coral reef" type. Evidence that this cannot be considered a truly representative tropical type is found in the fact that the Canaries in the tropical Atlantic, whose physical characteristics, apart from the temperature of the water, are very different from those of any of the three other areas already considered, possess a Medusa fauna of markedly different characters.

As I have already stated, all of the Leptoline Hydromedusae from the Maldives, with one possible exception, are new. At the same time all of the Trachylinae which belong to the families Geryonidae and Peganthidae, whose members are well known to be local in their distribution, are also new. In other words, all the "local" forms, with one possible exception, are new, and the only species of Hydromedusae already known are those distributed, or at least represented, by exceedingly close allies throughout the tropical oceans of the globe. This same rule holds good for the Discomedusae, Aurelia, and Nausithoe, the Siphonophores and Ctenophores. We reasonably expect to find traces of such a condition in almost any region. The striking thing in the Maldives is the extent to which it is seen; for not only do we find nearly all the local forms new, but we find them separated from their nearest allies by very considerable divergences which amount often nearly to generic importance. The frequent occurrence in the Maldives of very aberrant species in genera which until now have been very homogeneous is a striking feature. The main conclusions which I wish to draw from these facts are two: — first, the very large proportion of new forms among those groups whose members are known to be of somewhat local distribution, particularly the Leptolina, and the fact that none of the typical Atlantic or Pacific Leptolina were found, points to the conclusion that, so far as the Medusa fauna is concerned, the Maldives are an area of geographic isolation. The very considerable degree of divergence from their near allies shown by the new species, and the frequent occurrence of aberrant members in otherwise very homogeneous genera, points to the second important conclusion, that this condition of isolation has lasted for a considerable period.

The fact that all but one of the genera of Acalephs found in the Maldives occur in the Atlantic, while only about two thirds of them are known to occur in the Pacific; and that while we found no typically Pacific genus, we did take five genera not previously recorded, except from the Atlantic, — seems to point to a closer connection with the Atlantic than with the Pacific. This connection, if it exists, is of very great interest in view of the well-known general resemblance between the Pacific and Indian oceans, as shown by their Fishes, and particularly their Echinoderms, of which the same species are known to occur off Zanzibar, and off the west coast of South America.

ALPHABETICAL LIST OF SPECIES.

Hydromedusae.

Scyphomedusae.

Siphonophorae.

Ctenophorae.

DESCRIPTION OF THE SPECIES.

I. HYDROMEDUSAE.

Dipurena fragilis.

Dipurena fragilis Mayer, A. G., 1900. Bull. Mus. Comp. Zoöl., vol. 37, p. 28, plate 17.

This Medusa, if not identical with Dipurena fragilis Mayer, from the Tortugas, is very closely allied to it. It appears to differ from it in being colorless, and in having the swollen regions on the proboscis much less prominent. The fact that only one specimen was taken makes me hesitate to separate it specifically.

January 2. Suvadiva atoll, near Dandu island; surface.

The occurrence of Dipurena in the Indian Ocean is of interest, since this genus has never been taken in the tropical Pacific, though in the tropical Atlantic and Mediterranean it is represented by numerous species.

Euphysa tetrabrachia, sp. nov.

Plate 1, Fig. 1.

I have rather doubtfully referred the present species to Euphysa, to which genus it shows more resemblance than to Corymorpha. The bell is four mm. high by two and one half broad; pear-shaped, with a low and broad apical projection, and it is perfectly symmetrical. The single long tentacle is well developed, and is about four times as long as the bell is high. The other three, instead of being mere rudiments, are of considerable size, about one third as long as the bell height, and are equally developed. All four are ringed with nettle cells, about three rings on each of the short, and six or eight on the long, tentacle.

There is an ocellar bulb borne at the base of each tentacle. The proboscis is flask-shaped, its upper portion distended by the swollen half-spherical masses of gonads, arranged in eight fairly distinct rows. The mouth hangs below the bell opening, and bears no lips.

The bell is colorless and very transparent, the gonads brownish yellow, the proboscis slightly pinkish, and the ocellar bulbs and rings of nettle cells rose pink.

One specimen, January 7, in Suvadiva atoll. Surface.

The generic position of this very distinct species seems doubtful. It agrees with Euphysa in the symmetry of the bell, and in the arrangement of the gonads, which correspond very well to the figures of Euphysa virgulata, given by Alexander Agassiz (North American Acalephae, 1865, p. 190, fig. 317).

It differs, however, from both Euphysa and Corymorpha in the considerable and equal development of the three short tentacles, and further study may prove it to be representative of a new genus.

Turritopsis, sp.

A single young specimen of Turritopsis was taken in the tow on January 10, in Felidu atoll. Species undetermined.

Bougainvillia, sp.

A single specimen of Bougainvillia, in a very fragmentary condition, was taken in the tow on December 30, off the east face of Kolumadulu atoll, in an open net at one hundred fathoms.

Berenice, sp.

A single specimen of Berenice was taken in the tow on the night of January 8, in Haddummati atoll. It was too fragmentary for description.

Oceania virens, sp. nov.

Plate 1, Figs. 3, 4.

The bell is lenticular, with rather thin but firm gelatinous substance, about twelve mm. in diameter and one third as high. There are between sixteen and twenty tentacles, the exact number being variable, irregularly arranged. Each tentacle is thick, swollen at the base, only slightly contractile, and about one half as long as the bell-height. Besides the tentacles there are from thirty to forty rudimentary tentacular bulbs borne on the bell margin, two or three between each two tentacles. These knobs, however, are irregularly arranged, and vary greatly in number in different specimens. They appear never to be developed into anything more than the mere rudiments of tentacles or cirri. The proboscis is short, flask-shaped, very distensible, and bears four simple pointed lips. The gonads are long for this genus, occupying the distal half of the radial canals.

There are thirty-two otocysts, two or three between each pair of tentacles, but rather irregularly distributed. Each contains one or two spherical otoliths.

The bell is colorless. The gonads, proboscis, and tentacles are light yellowish green.

Several specimens, December 26, Male atoll, near Male island, and January 2 in Suvadiva atoll, near Dandu island, surface.

In form, arrangement of the gonads and otoliths, and in general appearance, this species much resembles Oceania pacifica Agassiz and Mayer (Bull. Mus. Comp. Zoöl., vol. 32, no. 9), from Fiji. It differs from it strikingly, however, in the possession of rudimentary tentacular bulbs on the bell margin, in which respect it resembles Oceania carolinae Mayer, from the western Atlantic, from which species it is clearly distinguished by the shape of the bell and the size and position of the gonads.

Oceania brunescens, sp. nov.

Plate 1, Fig 2.

The bell is low and flat, about two mm. in diameter and one third as high. There are about thirty short thick tentacles, much swollen at the base. The bell margin does not bear tentacular bulbs. The proboscis is very short and broad, and the mouth bears four simple lips. The most distinctive feature of this Medusa are the gonads, which are exceedingly thick and prominent, and nearly hemispherical (Plate 1, Fig. 2). They occupy the proximal third of the radial canals.

There are from thirty-two to forty small otocysts, each with one or two otoliths, scattered irregularly along the bell margin.

The bell is colorless and very transparent. The canals and gonads are greenish yellow. The tentacles are colorless, but at the base of each there is a prominent brown pigment spot.

Two specimens, January 15, near the southern end of Malosmadulu atoll. The very large, hemispherical gonads and prominent brown pigment spots clearly distinguish this Medusa from all described species of Oceania.

Eutimeta lactea, sp. nov.

Plate 2, Figs. 7, 8.

The bell is thin, slightly conical, nine mm. in diameter, and about one half as high. There are eight permanent and well-developed tentacles, of which the four opposite the radial canals are about as long as the diameter of the bell, and the other four slightly shorter. Small lateral spurs are borne at the bases of the tentacles, and there are in addition about twenty-four papillae on the bell margin. None of these bear lateral cirri. There are eight otocysts, each of which contains four or five otoliths. The peduncle of the proboscis is slender and slightly shorter than the bell diameter. The proboscis is cylindrical and as long as $\frac{2}{3}$ of the bell height. The mouth bears four slightly foliated lips. The position of the gonads is somewhat distinctive. They are borne on the radial canals, and occupy the central two thirds of the peduncle, as figured by Haeckel for Eutimeta gentiana (System der Medusen, 1880, plate 12, fig. 7). In Eutimeta levuka Agassiz and Mayer, from Fiji, they are found near the circular canal. The gonads are of considerable size, and form four swollen ridges.

This species is nearly colorless: the tentacles and manubrium are of a very faint bluish tinge, and the gonads are opaque milky white.

Several specimens, Male atoll, near Male island, December 26, surface.

This species is most closely allied to Eutimeta gentiana Haeckel, from the Canaries, but differs from it in the form of the bell, and in having much smaller marginal cirri. The gonads are more prominent, but occupy a shorter portion of the peduncle. In the form of the bell it resembles Eutimeta levuka Agassiz and Mayer, but the peripheral position of the gonads in the latter is an important point of difference.

Eirene danduensis, sp. nov.

Plate 1, Fig. 5. Plate 2, Fig. 6.

The bell is flatter than a hemisphere, somewhat conical in outline, with rather thin gelatinous substance: it is twenty-five mm. in diameter and about one third as high. There are thirty-two tentacles, of which the four opposite the radial canals are at least one fourth longer than the others. Each tentacle bears two lateral cirri at its base, and there are also about seventy small papillae scattered irregularly along the bell margin. There are thirty-two otocysts, eight to each quadrant, and each contains about five spherical otoliths. The peduncle, the most distinctive feature of this form, is long for the genus, reaching well below the bell opening, and is conical in outline. The proboscis is about one half as long as the peduncle. It may be extended to nearly double this length, but cannot be retracted within the bell opening. The mouth bears four simple lips.

The spindle-shaped gonads occupy the distal two thirds of the radial canals. The bell is colorless. The gonads are bluish green.

A single specimen was taken on January 8, off the east face of Haddummati atoll, in an open net, at two hundred fathoms.

This Medusa is distinguished from all described species of Eirene by the very considerable length of the peduncle and proboscis.

Timoides agassizii, gen. et sp. nov.

Plate 3, Figs. 10, 11.

Timoides forms a new genus of Eucopidae, belonging to that division of the family characterized by possessing numerous otocysts and tentacles, and numerous cirri on the bell margin. The gonads are borne on the radial canals, but are wholly restricted to the peduncle, which is very long. The lips are large and form an important feature. By far the most characteristic feature of this genus, which in the main resembles Tima, is the presence, between the radial canals, of blind centripetal canals arising from the ring canal.

The Medusa is bell-shaped, of much the same outline as Tima formosa Agassiz. The gelatinous substance of the bell is very thick. The extreme diameter is twenty mm.; and the bell is two thirds as high as broad. The tentacles may be extended to nearly a foot in length, and are exceedingly flexible and contractile. When retracted they are usually coiled spirally, and this coiling may take place at any point in their length without affecting the rest of the tentacle. In life they stream out far behind the bell. They are thirty-two in number, arranged in four series. First, four, opposite the radial canals; second, four alternating with these; third, eight, alternating with the eight already mentioned. Every tentacle of these three series is opposite a canal, blind or radial; but the sixteen of the fourth series alternate with the canals. The bell margin also bears numerous cirri (Plate 4, Fig. 11), which, as well as the tentacles, are spirally coiled when retracted. Neither cirri nor tentacles bear lateral spurs.

The blind canals, which are the most important structural features of the Medusa, are arranged in two series, the first of four, alternating with the radial canals, and reaching up for two thirds the height of the bell; the second of eight, about one half as long, and alternating with the radials and blind canals of the first series. They are all in free communication with the ring canal, and each is opposite a tentacle.

The peduncle hangs below the bell opening for a distance at least equal to the height of the bell cavity. Throughout most of its length it is nearly cylindrical, but at its base it is somewhat funnel-shaped. At its distal end it passes, without any external separation, into the stomach, which is barrel-shaped in outline, and bears four prominent lips. These lips are, in life, the most striking feature of the Medusa. They are very long, and so extensible that they may reach a length considerably greater than that of peduncle and stomach combined. They are rather narrow, and their edges are thrown into innumerable constantly changing folds.

The gonads consist of a great number of simple and branched papilliform processes so closely crowded on the alternate sides of the radial canals that they form four prominent double ridges. They occupy slightly more than the distal half of the peduncle, and their relative extension seems, in adult specimens, to be practically invariable.

The coloring of this Medusa is exceedingly brilliant. The gelatinous substance of the bell is faintly tinged with blue: the gonads are rich Indian yellow, changing in certain lights to ruddy orange. In sharp contrast to them, the stomach and mouth arms are pink-violet; the radial canals and tentacles are rose pink, and there is a pink pigment spot at the base of every tentacle.

Abundant in Haddummati atoll, near Gadu island, on January 8. It appeared on the surface in great numbers at about four o'clock in the afternoon, when the bright colors and long streaming tentacles of the animals made them very conspicuous objects.

The fact that blind canals have never before been detected in the adult of any species of Eucopidae is at once sufficient to separate Timoides generically. The number of these canals and the relative extension of the gonads will probably prove to be of specific importance.

Gonionemus pelagicus, sp. nov.

Plate 4, Figs. 12, 13, 14.

The bell is rounded, but low and thin. It is about twenty mm. in diameter, and one third as high as broad. There are about fifty long, straight, flexible tentacles, each of which forms a slight elbow near the tip, in the manner characteristic of the genus. These elbows, however, are so inconspicuous in life that the tentacles resemble Melicertum rather than Gonionemus. At the elbow each tentacle bears a small almost rudimentary sucking disc, and they are ringed throughout their whole length. At the base of each there is a cluster of brown pigment spots. There are sixteen otocysts.

The proboscis is flask-shaped, nearly as broad as long. It is exceedingly flexible, but cannot be retracted. The mouth bears four fimbriated lips. The gonads, which occupy the distal third of the radial canals, consist of simple papilliform processes closely crowded together, as in Gonionemus murbachi, from Woods Holl, Mass.

The bell is colorless: the proboscis and tentacles are yellowish green, the pigment spots at the bases of the tentacles vandyke brown, and the gonads rose pink.

In life this Medusa bears little resemblance to other species of Gonionemus. It swims freely by frequent contractions of the bell, the tentacles streaming behind at full length. The flexible tentacles are continually contracting and expanding and swaying to and fro in the water. The Medusa showed no inclination to attach itself, nor did it swim to the surface, sink, and then swim up again in the manner so characteristic of the genus. The anatomical structure of the tentacles also points to this habit of life, which has led me to give it the name "pelagicus." It differs from all other species of Gonionemus, to which genus it certainly belongs, in the rudimentary condition of the sucking discs. One specimen, January 7, near Gadu island, Suvadiva atoll, surface.

Messonema coerulescens Brandt.

Brandt, 1838, Mem. Acad. Imp. St. Pétersbourg, ser. 6, vol. 4.

A single specimen of Messonema was taken on January 8, in Haddummati atoll. It probably belongs to this species, but was too fragmentary for accurate determination.

Rhopalonema typicum Maas.

Homoeonema typicum Maas, 1897, Mem. Mus. Comp. Zoöl., vol 22, p. 22, taf. 3.

Two specimens of this species were taken on January 8, in Haddummati atoll.

Aglaura prismatica Maas.

Aglaura prismatica Maas, 1897, Mem. Mus. Comp. Zoöl., vol. 12, p. 24, taf. 3.
Lessonia radiata? Eydoux et Souleyet, 1841–52, Voyage de la Bonité, vol. 2, Zoöphytes, plate 2.

A species of Aglaura apparently identical with the Aglaura prismatica of Maas was one of the most abundant Medusae in the tow. We took it at almost every station, both inside and outside the atolls, often in large numbers. All our specimens were quite colorless and transparent, a condition similar to that observed by Agassiz and Mayer in several specimens from Fiji (Bull. Mus. Comp. Zoöl., vol. 32, p. 165, plate 4, fig. 13).

Aglaura octagona, sp. nov.

Plate 2, Fig. 9.

The bell is distinctly octagonal, lantern-shaped, and flattened at the top; it is three mm. high, and about one half as broad. The walls, although exceedingly thin, are very rigid, and the vellum is provided with a series of circular muscles. There are about thirty-two tentacles, which in our specimens were all broken short off, leaving stumps behind. The peduncle is three fourths as long as the bell is high and cannot be retracted within the bell cavity. The stomach is short and globular, and the mouth bears four simple lips, which hang nearly on a level with the bell opening. The gonads are egg-shaped, and are borne at the junction of the radial canals with the stomach. There are eight interradial otocysts. The whole Medusa is perfectly colorless.

Two specimens, December 30, off the east face of Kolumadulu atoll, in an open net at about one hundred fathoms. Aglaura octagona is very closely allied to Aglaura laterna Haeckel, from the Canary Islands. It differs, however, in the following particulars: The peduncle is longer, the gonads are egg-shaped instead of spherical, and the tentacles seem rather more numerous. (Aglaura laterna has usually from sixteen to twenty-four.) The form of the bell in both species is identical, and in other general proportions they are very similar. The genus Aglaura falls into two well-marked divisions, one represented by Aglaura hemistoma, with the closely allied varieties, prismatica Maas, from the Pacific, nausicaa Haeckel and vitrea Fewkes, from the Atlantic, characterized by the short peduncle; and the other represented by Aglaura laterna Haeckel, from the Canaries, and Aglaura octagona, sharply distinguished by the long peduncle and lantern-shaped bell. I think it is probable that these may all prove to be merely geographical races of two well-defined species.

Liriope Lesson, 1843.

In the "Craspedoten Medusen der Deutschen Tiefsee-expedition," p. 79, Dr. Ernst Vanhöffen has given an able analysis of this genus which he, following Maas and Metschnikoff (Arb. Zoöl. Inst., Vienna, vol. 6), widens to include all Geryonidae with four radial canals. He thus includes Haeckel's genera Glossocodon and Glossoconus (Haeckel, System der Medusen, 1879), of which the distinctive character, the presence in the adult state of blind centripetal canals, has been shown by Maas to be a developmental feature of little systematic importance. Although knowledge of the young stages of most species of Liriope is entirely lacking, or very fragmentary, Maas, writing of the collections of the Plankton Expedition (Craspedoten Medusen der Plankton Ex. 18), was able to say: "Of all the material of the expedition, no single species of the Geryonidae can be named, of which it can safely be said that it has no centripetal canals."

Our catch included two species of Liriope, both of which appear to be new.

Liriope indica, sp. nov.

Plate 5, Figs. 17, 18.

This species is one of the medium-sized members of the genus, measuring in diameter fourteen mm., and in height about nine. The outline of the bell is almost an exact segment of a circle (Plate **5**, Fig. 17), and the gelatinous substance is of medium thickness, thus agreeing well with Vanhöffen's statement that the thickness of the gelatinous walls of members of this genus correspond in general to their size. The eight permanent tentacles are very unequal; the four opposite the radial canals are hollow, flexible, ringed with nettle cells, about as long as the bell diameter. Although they are moved actively, they seem only very slightly contractile, so that their length varies but little. Alternating with them are four others, only about one fourth as long, which are solid, stiff, and curved outwards. Their centripetal surfaces are set with ridges of nettle cells, which extend around about one half the circumference of the tentacle. The ring canal does not give rise to any blind canals, but opposite each of the short tentacles it becomes abruptly broader, forming a triangular spur (Plate **5**, Fig. 18). The peduncle is nearly cylindrical, about as long as the bell is high, and hangs far below the bell opening. The stomach is one third as long as the peduncle, and does not bear a stomatostyle. The mouth is a simple, square opening, without lips. The gonads, which occupy nearly the whole length of the radial canals, are shield-shaped, and so broad that they occupy one third of the surface of the subumbrella. The eight otocysts are borne one at the base of each tentacle. Their position, however, differs: the ones corresponding to the short tentacles occurring directly above them, while the four connected with the long tentacles are at one side (Plate **5**, Fig. 17). The Medusa is perfectly transparent and colorless, except that the gonads are opaque yellowish, and the nettle knots on the short tentacles reddish brown.

Four specimens, January 2, in Suvadiva atoll, near Dandu island, surface. This Medusa in several respects resembles the Liriope hyalina of Agassiz and

Mayer (Bull. Mus. Comp. Zoöl., vol. 30, p. 166, plate 9). Mayer's figure appears to be taken from an immature individual, and in his description he makes no mention of the form of the gonads, so it is possible that the two species may prove to be identical. Both are closely allied to Liriope scutigera McCrady (Proc. Eliott Soc. Nat. Hist., vol. 1, p. 208, 1859), from Charleston Harbor, South Carolina.

Liriope hemisphericus, sp. nov.

Plate 4, Figs. 15, 16.

The bell is nearly hemispherical, with rather thick walls. It is eight mm. in diameter and slightly more than half as high as broad. The bell cavity is flatter than a hemisphere. There are two kinds of chymiferous tubes. There are four radial canals, and alternating with these are four broad, arrow-shaped canals which arise from the ring canal and end blindly in the bell wall at about one half the height of the cavity. Corresponding to these two kinds of canals are two kinds of tentacles. The four opposite the radial canals are hollow, flexible, about as long as the bell is high, and ringed with nettle cells throughout their length. Alternating with these, and opposite the blind canals, are four others which are only slightly shorter, but are solid, stiff, and carried curved sharply outward. Instead of being ringed, they bear a series of clusters of nettle cells on their centripetal surfaces (Plate **4**, Fig. 16). The cylindrical peduncle, which is very flexible, is nearly as long as the diameter of the bell, and so hangs far below the opening. Its distal end is prolonged into a pointed stomatostyle. The stomach is nearly cylindrical and the mouth bears four simple lanceolate lips which are usually recurved. The gonads are heart-shaped, rather narrow, and occupy the proximal half of the radial canals. They occupy hardly more than one eighth of the surface of the subumbrella. The eight otocysts, which are all similar, are arranged radially and interradially, the radials being at one side of the tentacles, the interradials directly above their bases (Plate **4**, Fig. 16). This Medusa is colorless, except that the gonads are opaque whitish, and the nettle cells on the short tentacles Vandyke brown.

Three specimens, December 26, Male atoll, near Male island, surface. This species differs in important particulars from all known members of that division of the genus Liriope whose adult members normally possess centripetal canals, in having only one of the latter to each quadrant, — a condition characteristic of the young of other species. In general appearance it most resembles Liriope tenuirostris Agassiz, from the Atlantic coast of North America. A striking characteristic of the species is the large size of the interradial canals.

Although our specimens were sexually mature, it is by no means certain that the number of blind canals had reached its maximum. Studies on a species of Olindias from Bermuda have shown a condition in which the number of these canals and of the tentacles nearly doubles with the increase in size of the Medusa after sexual maturity is reached; and it is by no means improbable that the same may be true here. As in the case of the velar canals of Charybdea, so here the number and even form of the blind centripetal canals are probably chiefly dependent upon age, and cannot be considered of much systematic importance.

Pegantha simplex, sp. nov.

Plate 5, Figs. 19, 20.

This Medusa has the form characteristic of the genus. The bell consists of a thick, lenticular central portion, surrounded by a dependent ring or collar, from which it is divided by a shallow furrow. The margin of the collar is divided into eight lappets, each of which is in turn subdivided into two by a shallow groove. The lappets are very flexible, and can be curved inward, so that they nearly close the bell opening. The bell is about three mm. in diameter, and one half as high as broad. There are only eight tentacles, a much smaller number than has been reported for any other species of the genus; and this number seems to be constant. They arise from the periphery of the central disc, alternating with the eight marginal lappets, and corresponding to the grooves between them. They are broadly conical at the base, solid, carried curved stiffly outward, and are slightly longer than the bell is high. They taper very rapidly, and toward the tips are very delicate. A characteristic feature of this Medusa, in which there are no radial canals, is the large size of the stomach. This organ, which is lenticular in cross-section and provided with a broad, simple mouth without lips, extends to the periphery of the central disc. In outline it is somewhat octagonal, the angles being opposite the tentacles, and from the middle of each side (alternating with the tentacles) it throws out a narrow canal running to the corresponding gonad, one of which lies at about the middle of each marginal lappet. The gonads are sac-shaped bodies, of considerable size, suspended from the surface of the subumbrella. In this Medusa they are simple, although in most other species of the genus they are subdivided into three or more secondary lobes. There are about two hundred otocysts, situated on the edges of the marginal lappets, about twenty-five to each lappet. Each otocyst arises from a low and broad "auditory papilla," which is thickly set with short stiff ciliae. The otocysts themselves are oval, and contain three rather long prismatic otoliths. At their bases they bear club-shaped processes, about twice as long as the otocyst, which extend up into the substance of the bell. When the lappets are retracted over the bell opening, these processes alone are visible.

The Medusa is altogether colorless. An abundant species: numerous specimens, December 26, Male atoll, near Male island; January 2, off the east face of Kolumadulu atoll, in an open net at fifty and one hundred fathoms; January 15, Malosmadulu atoll, surface. One of the few species which appeared to be equally common inside and outside the atolls.

This form seems quite distinct from all other species of Pegantha, to which genus it undoubtedly belongs. Its two striking peculiarities are the small number of tentacles, and the fact that the gonads are not subdivided. The smallest number of tentacles described from any species of the genus is fourteen, in Pegantha martagon (Haeckel, System, 1879).

Aeginella dissonema Haeckel.

Haeckel, 1879, Syst. der Medusen, p. 340, taf. 20, fig. 16.

We took one specimen of this Medusa in South Malosmadulu atoll, January 15, surface. Drawings made from life agree perfectly with the figures given by Haeckel (System, taf. 20), and by Mayer (Bull. Mus. Comp. Zoöl., vol. 37, plate 14, fig. 30), except that our specimen was altogether colorless, instead of having green pigment spots on the stomach. The only other described species, Aeginella bitentaculata Quoy et Gaimard, seems to differ very slightly from Aeginella dissonema Haeckel.

II. SCYPHOMEDUSAE.

Aurelia maldivensis, sp. nov.

Plates 6 and 8, Figs. 22, 23, 27.

This Medusa is by far the most aberrant species of Aurelia, to which genus I rather doubtfully refer it. The bell is disc-shaped, of very solid consistency, and rather thick; it is about two hundred and fifty mm. in diameter, and slightly more than one third as high as broad. Its outline is broken by eight deep indentations, forming eight marginal lappets, each of which bears a slight central depression at its margin. At the base of each of the eight indentations lies a prominent sense organ (Plate **6**, Fig. 23). In their proportions these sense organs differ considerably from those of Aurelia flavidula Pér. et Less., although they agree with them in general structure. They differ, however, in their connection with the stomach, which here consists of a single straight radial canal, which instead of opening into a broad circular cavity, connecting on either side of the sense organ with the ring canal, spreads but slightly, forming only a small cavity, which sends out two narrow branches, one on either side of the sense organ, to the ring canal. No other chymiferous vessels open into this enlarged cavity, except that it usually anastomoses with the neighboring radial canal on either side. This condition is, however, not constant. There are three short canals which arise from under the floor of the expanded cavity. One of these is broad, short, and runs to the otocyst; the other two form a horseshoe, embracing the otocyst, and run into the two marginal papillae, near the outer edges. These papillae are large and prominent, but extend only slightly, if at all, beyond the margin of the bell. The otocyst itself, containing a number of minute spherical otoliths, is covered over by a curtain-like structure (Plate 6, Fig. 23).

The tentacles, borne on the exumbrella, some distance from the bell margin, are short, very numerous, about five hundred in number, and alternate with as many small dorsal lappets. There are about forty-eight chymiferous tubes in the region of the stomach, but they branch frequently, and occasionally anastomose, so that at the bell margin there are about one hundred and seventy to one hundred and seventy-five. The eight canals running to the sense organs do not branch, nor do the eight which run to the middle of the marginal lappets. The mouth arms are long and broad, fringed with innumerable minute tentacles, and in life they hang slightly below the bell opening, but do not extend outward beyond its margin. The structure of the mouth parts, and their complexity, separates this Medusa from every other member of the genus. The mouth itself is a simple cruciform opening, but it is surrounded by elongated lips, which hang far below the bell opening, suggesting in appearance a small or immature Cyanea. These lips, which are undivided, and form an extremely sensitive and mobile curtain completely surrounding the mouth, are thrown into four main folds, rendering them cruciform in cross-section, and alternating in position with the gonads. They bear in addition numerous complex lesser folds, increasing in number toward the free margins. The living Medusa constantly contracts and expands the mouth parts with every motion of the bell, and a photograph taken at the time shows them much further extended than I have figured them. The four gonads are of the horseshoe form typical of Aurelia, and are rather small. But owing to their bright color they are very conspicuous. The subgenital pits are widely opened.

This Medusa is extremely brilliant and striking in the water. The entire bell is of a delicate lilac tinge; the canals and tentacles are pinkish violet, and the gonads, and in mature specimens the edges of the mouth arms and lips are bright violet. The color varies much, — some specimens showing more pink, others more violet or blue.

Abundant on the surface on several occasions. We found it first on January 1, off the east face of Suvadiva atoll, and inside the atoll, when it was so abundant that it filled regular lanes in the water, and the tow brought in nothing else. After that we found it in nearly every other atoll.

Aurelia maldivensis bears little resemblance in appearance to any other Aurelia, and this is especially important in a genus where all the other species are extremely closely allied. The most striking feature of this Medusa is, of course, the great development of the mouth parts, which, as I have noted, suggest in their structure the young of Cyanea; but the arrangement of the chymiferous tubes and the structure of the sense organs are also both distinctive.

Nausithoe punctata KÖLLIKER.

Kölliker, 1853, Zeit. für Wiss. Zoologie, bd. IV.
Nausithoe punctata, var. Pacifica, Agassiz & Mayer, 1902, Mem. Mus. Comp. Zoöl., vol. 26.

Plate 6, Fig. 21.

In the descriptions and figures of this genus, given by Kölliker, Agassiz and Mayer, Mayer, Haeckel, and Gegenbauer, there has been a great deal of confusion as to the relative radial positions of the marginal tentacles, gonads, and groups of gastric cirri. Kölliker, who established the genus, figures Nausithoe punctata with the gastric cirri and gonads in the tentacular radii (Zeit. für Wiss. Zool., bd. 4, p. 323). Gegenbauer, who has given the best figures of this species, followed his example (Arch. Anat. and Phys., 1853, p. 239). Haeckel (System, part 2, 1879) says that the gastric cirri are in the radii of the sense organs (gonads and tentacles adradial); while Mayer says of Nausithoe punctata that the gastric cirri lie in the radii of the marginal sense organs, but in his figures they are in the tentacular radii! (Bull. Mus. Comp. Zoöl., vol. 37, no. 2.) Finally, Agassiz and Mayer (Mem. M. C. Z., vol. 26, no. 3, 1902) figure Nausithoe punctata var. pacifica and Nausithoe picta with them in the tentacular radii.

In our specimens the arrangement was as follows. The four angles of the mouth, and the four groups of gastric cirri which alternate with them, are in the radii of the eight marginal sense organs. The eight gonads lie in the radii of the eight tentacles. There are thus sixteen distinct radii, eight tentacular, in which lie the eight gonads, and eight ocellar, corresponding to the four groups of gastric cirri, and the four arms of the cruciform mouth. This agrees with Haeckel's statement and Mayer's description.

The bell is flat, of the Ephyra-like outline typical of the genus, seven to nine mm. in diameter. There are eight stiff, solid tentacles arising from the clefts between the eight marginal lobes. Each marginal lobe is subdivided into two lappets, and between each two lappets there is a sense organ. Each sense organ contains a spherical otocyst and a proximal dark-brown ocellus, provided with two nerve fibres and a lens. The mouth is cruciform, and alternating with the arms of the cross there are four groups of gastric cirri, from two to five in each group. The eight gonads are pale reddish-brown. There is a ring of circular muscle fibres, occupying most of the subumbrella between the bases of the tentacles and the periphery of the stomach, and a strand of radial fibres runs from near the stomach out into each of the sixteen marginal lappets.

Seven specimens of different ages. December 26, Male atoll, near Male island, surface. January 2, Suvadiva atoll, near Dandu island, surface.

This form is very close to Nausithoe punctata, from which it differs only in the brighter color of the gonads, and the rarity of yellow pigment spots on the exumbrella, features of which the systematic importance is too slight to warrant the establishment of a new variety.

III. SIPHONOPHORAE.

Porpita lutkeana Brandt.

Brandt, 1825, Mem. Acad. Imp. St. Petersbourg Sci. nat. ser. 6, tome IV.

Plate 7, Figs. 24, 25, 26.

It is with considerable hesitation that I refer our specimens of this genus to the Porpita lutkeana of Brandt, which seems, however, to fit them better than any other described species of Porpita. The Pacific and Indian forms of the genus have always been in confusion, owing to the fact that most of the early descriptions are altogether insufficient for identification. Haeckel (Siphonophorae of the "Challenger" Expedition) recognizes, besides the well-known Atlantic forms, Porpita lutkeana Brandt, to which he gives the synonym, Porpita indica (see ibid.); Porpita pacifica Lesson = Porpita gigantea Péron et Lesueur; Porpita australis Haeckel (System der Siphonophoren); and Porpita fungia Haeckel (Siphonophorae of the "Challenger" Exped.).

Porpita lutkeana agrees in general with our specimens, although Brandt's description is so meagre that an accurate determination is very difficult.

The disc, in the largest specimen, measured forty-five mm. in diameter and five mm. in thickness. The upper, external surface of the exumbrella bears a series of minute knobs and corrugations, making it rough to the touch. The central chamber and the eight primary radial chambers are large, and communicate with the exterior by prominent stigmata. Over the rest of the exumbrella the stigmata are very irregularly arranged. There are thirty-two circular partitions, at nearly equal distances, dividing the pneumatocyst into as many circular chambers, which are in communication with each other through openings in the circular partitions. The floor of the float cavity is thrown into a series of deep radial furrows and ridges, which interlock with the underlying ridges and furrows of the liver. These corrugations arise at the centre as eight folds, which by branching come to number about sixty. In addition to these and alternating with them, a series of shorter folds, arising at the periphery, runs centripetal for a short distance between the original centrifugal ridges, making the total number at the margin about one hundred and twenty.

The liver is of considerable thickness, completely filling the space between the bottom of the float cavity and the lower surface of the disk, where it communicates with the bases of the reproductive polypites.

There are about two hundred tentacles, arranged in about four or five concentric rows, instead of the nine rows described by Brandt. When fully extended they are about as long as the diameter of the disc. Each tentacle bears three distinct rows of knobs, in the manner typical of the genus. At the tip of the tentacle there is a cluster of four, and this number appears invariable. In each row there are about ten knobs.

The central sterile polypite is large, with smooth walls, and very distensible.

The remainder of the lower surface of the disc, between the central polypite and the tentacular zone, is completely covered by the long, slender feeding and reproductive polypites, bearing at their bases clusters of Medusae in all stages of development. These Medusae agree very well with the figures given by Alexander Agassiz for Porpita linneana. (Mem. Mus. Comp. Zoöl., vol. 8, no. 3.) Scattered among the reproductive polypites are a few of larger size, which seem to be sterile. Their heads are rounded and surrounded by four clusters of nettle cells. Our preserved specimens are unfortunately too imperfect to allow of histological investigation, so I have been unable to trace the number or position of the tracheae.

The characteristic external features of this species are: first, its intense Prussian blue color; second, the large size and extreme flatness of the disc; third, the shortness of the tentacles, and fourth, the great length of the feeding and reproductive polypites.

Diphyopsis appendiculata AGASSIZ and MAYER.

Diphyes appendiculata Eschscholtz, 1829, Syst. der Acalephs, p. 138, taf. 12, fig. 7.
Diphyes appendiculata Huxley, 1859, Oceanic Hydrozoa, p. 34, plate 1, figs. 2–2c.
Diphyopsis appendiculata Agassiz, A., and Mayer, A. G., 1899, Mem. Mus. Comp. Zoöl., vol. 26, no. 3, p. 160, plate 9.

A species of Diphyopsis, apparently identical with the Diphyopsis appendiculata of Agassiz and Mayer, was one of the most abundant Acalephs in the tow, and was taken at almost every station. The only distinction between it and the Pacific variety is that all our specimens were colorless, instead of having the polypites and nematocyst batteries yellowish or pinkish.

Physalia megalista PÉRON ET LESUEUR.

Physalia megalista Péron, F., et Lesueur, C. A., 1807, Voyage aux terres Australes, Mollusques et Zoophytes, plate 29, fig. 1.
Physalia megalista Haeckel, E., 1888, "Challenger" Report, Zoöl., vol. 28.

One specimen of Physalia belonging to this species was taken on January 19, off Tiladummati atoll. The pneumatocyst measured twenty-five mm. in length and was deep Prussian blue in color.

III. CTENOPHORAE.

Bolina ovalis, sp. nov.

Plate 8, Fig. 28.

This species appears closely allied to Bolina microptera A. Agassiz (N. Amer. Acalephs, 1865), and may prove to be identical with it. But the absence of figures of B. microptera leaves me in doubt. The animal is about fifty mm. in length, and in the broad diameter nearly half as wide. In general outline it resembles Bolina vitrea rather than Bolina septentrionalis Mertens. The lobes are, however, at least one third shorter than in Bolina vitrea, and the digestive cavity is proportionately longer, one third longer than the lobes. The auricles are similar in shape to those of Bolina vitrea. The apical sense organ is situated at the bottom of a deep cleft, and is provided with a series of radiating muscle fibres. There are from fifteen to eighteen vibratile combs in each of the short, and thirty to thirty-five in each of the long ciliary bands. Unfortunately in our single specimen the lobes were so damaged that the course of the chymiferous tubes could not be traced with accuracy. Enough, however, remained to show that they were no more complicated than in Bolina vitrea. This is the only point in which it disagrees with A. Agassiz's description of Bolina microptera.

Bolina, sp.?

On January 19, near Guradu Island, we took a single immature Ctenophore, which is probably a young Bolina. It is in the Pleurobrachia stage, figured by Chun (Mon. Ctenophoren), but the lateral lobes have already begun to appear, and the tentacles are short. The rows of vibratile combs extend nearly to the bases of the lobes. The mouth is a simple slit.

Ocyroe pteroessa, sp. nov.

Plate 8, Fig. 29.

The polar diameter of the animal is about twenty-five mm. The body is so much flattened that the narrow diameter is only one half the broad. The lateral lobes form large wing-like structures, one third longer than the polar diameter. The movements of the animal are effected by their vigorous flappings. The ciliated bands are short, containing but few combs. The auricles are short, being only one half as long as the polar diameter, and are always pointed upward. Their edges are lined with a series of stout cilia, set at considerable intervals. The digestive cavity is large, variable in form, but is not normally lobed. The windings of the chymiferous tubes are simple, much more so than in Ocyroe crystallina. The "spots" so characteristic of the lobes of Ocyroe maculata are wanting, but most of the substance of the lobes is occupied by stout muscle fibres which radiate to the periphery.

Ocyroe pteroessa is most closely allied to Ocyroe crystallina Rang, of which Fewkes and Mayer both give good figures (Bull. Mus. Comp. Zoöl., vol. 9, plate 1, and Bull. Mus. Comp. Zoöl., vol. 38, plate 31), but differs from it in several important particulars. The lobes are proportionately larger, the body narrower, the auricles very much shorter, about one half as long. The outline of the stomach is simple instead of lobed, and it is much shorter. The windings of the chymiferous tubes are much less complex, and the muscle fibres occupy more nearly the whole substance of the lobes.

Beroe, sp.

One young specimen of this genus was taken on January 19, near Guradu island, on the surface. It had arrived at nearly mature form, except that the rows of vibratile combs extended only about halfway from the apical pole to the mouth. The chymiferous tubes were put into communication by an extremely simple network similar to that described by Agassiz and Mayer for Beroe australis (Bull. Mus. Comp. Zoöl., vol. 32, p. 177, plate 16). It may be the young of that species.

Cestus pectenalis, sp. nov.

Plate 8, Fig. 30.

A species of Cestus was exceedingly abundant on January 19, on the surface near Guradu island, and on examination proved to be a wholly distinct species. In general form, as well as in its movements, it closely resembles Cestus veneris, but differs from it in the possession of a large and prominent orange spot at either end, and in the extent and structure of the ciliary bands. These extend from near the apical sense organ along the aboral edge of the band, following the chymiferous tube to the extremity of the lobe. They do not extend along the oral edge of the lobe, but come to an end at its extremity. The vibratile combs are comparatively few in number, and set at considerable distances from one another. The cilia are very long and rigid, presenting a comb-like appearance. The lateral flattening of the animal is excessive. The digestive cavity is broad, but short. The longest specimen captured measured one metre, by forty mm. in breadth; but the size was very variable. No Cestus with pigment patches has ever been described, and the comb-like structure of the ciliary bands, and their restriction to the aboral edge of the animal, are of even greater importance. It seems probable that further investigation may prove them to be of generic significance. Like Cestus veneris, this species is extremely graceful in the water, moving in slow, ribbon-like undulations, and shining with brilliant violet iridescence.

EXPLANATION OF PLATES.

oc., otocyst; *m. s.*, marginal sense organ.

PLATE 1.

Fig. 1. Euphysa tetrabrachia.
Fig. 2. Oceania brunescens.
Fig. 3. " virens.
Fig. 4. " " bell margin.
Fig. 5. Eirene danduensis, bell margin.

PLATE 2.

Fig. 6. Eirene danduensis.
Fig. 7. Eutimeta lactea.
Fig. 8. " " bell margin.
Fig. 9. Aglaura octagona.

PLATE 3.

Fig. 10. Timoides agassizii.
Fig. 11. " " bell margin.

PLATE 4.

Fig. 12. Gonionemus pelagicus.
Fig. 13. " " bell margin.
Fig. 14. " " tip of tentacle.
Fig. 15. Liriope hemisphericus.
Fig. 16. " " bell margin.

PLATE 5.

Fig. 17. Liriope indica.
Fig. 18. " " bell margin.
Fig. 19. Pegantha simplex.
Fig. 20. " " oral view.

PLATE 6.

Fig. 21. Nausithoe punctata.
Fig. 22. Aurelia maldivensis, radial canals, showing one octant of subumbrella.
Fig. 23. " " marginal sense organ.

PLATE 7.

Fig. 24. Porpita lutkeana.
Fig. 25. " " vertical section of disk; *s*, central stigmata; *cav*, central chamber; *c.*, circular partition; *R.*, white tubules; *H.*, brown hepatic tubules.
Fig. 26. Porpita lutkeana, reproductive polypite with budding Medusae.

PLATE 8.

Fig. 27. Aurelia maldivensis.
Fig. 28. Bolina ovalis.
Fig. 29. Ocyroe pteroessa.
Fig. 30. Cestus pectenalis.

PLATE 9.

Chart of the Maldive Archipelago, showing the track of the "Amra."
Reduced from Admiralty Charts 66 *a*, 66 *b*, 66 *c*; Sheets 1–3; Scale, 3.5″ = sixty miles corrected to May, 1903. Northern, Central, and Southern Maldives.

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H. B. B. del.

B. Meisel, lith. Boston.

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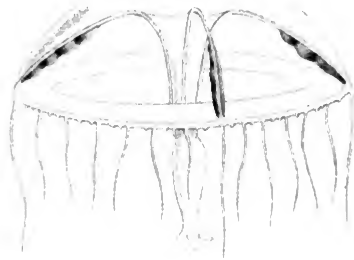

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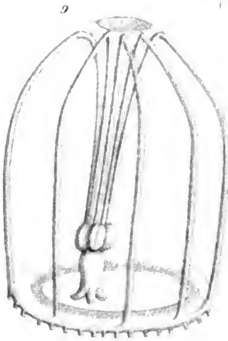

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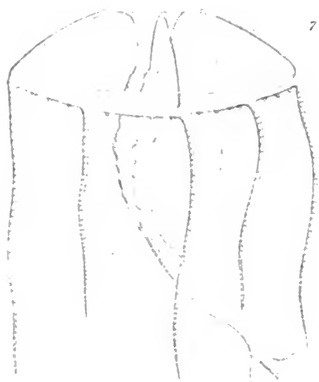

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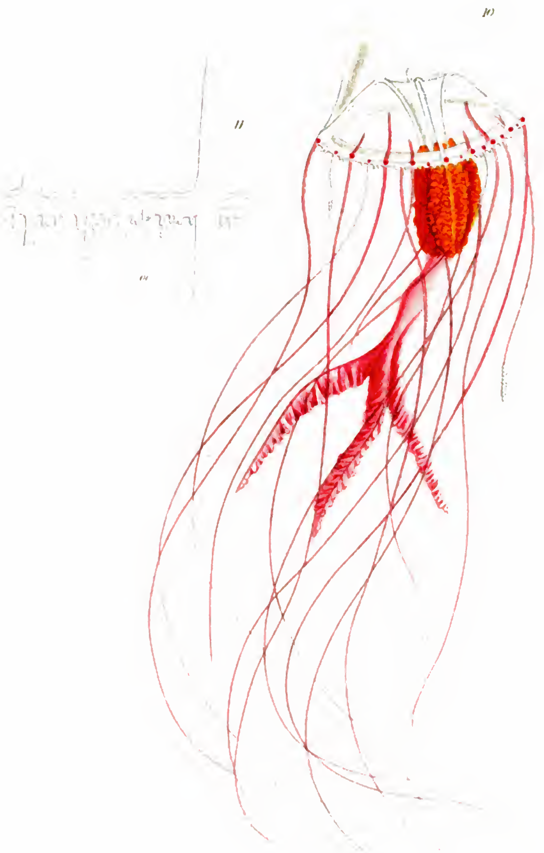

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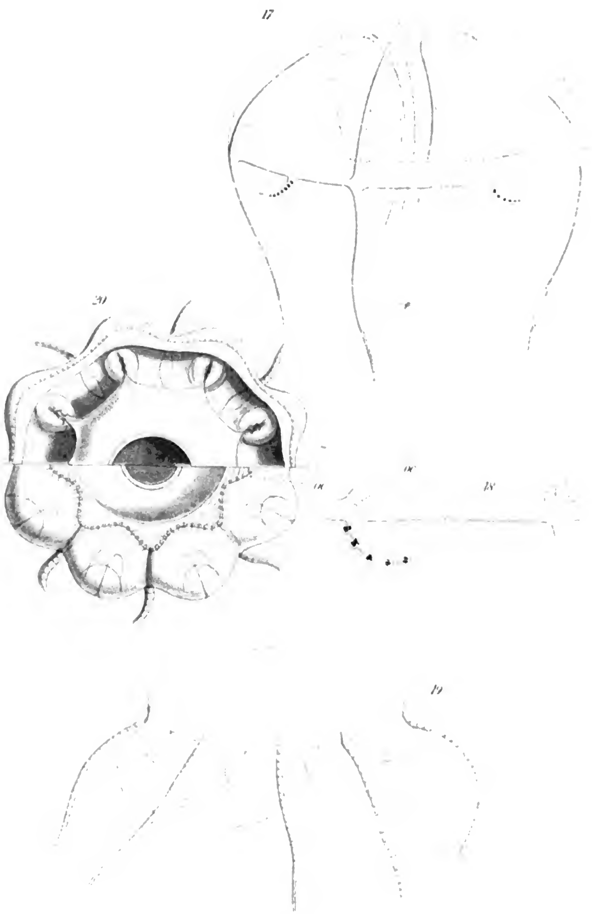
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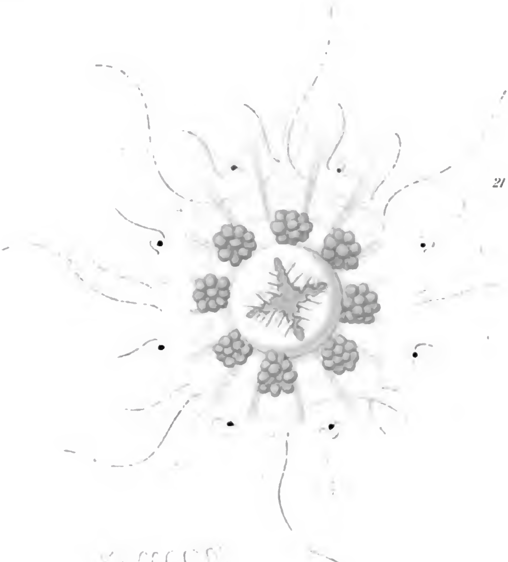

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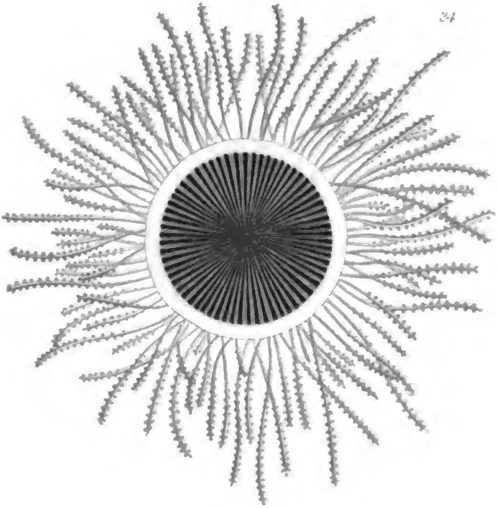
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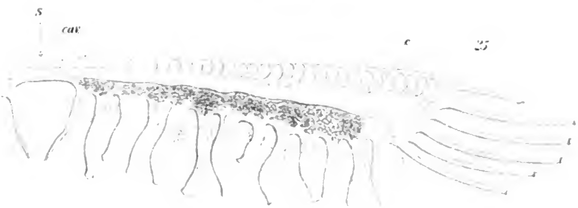
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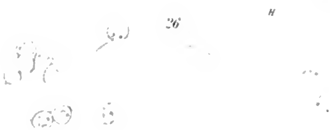
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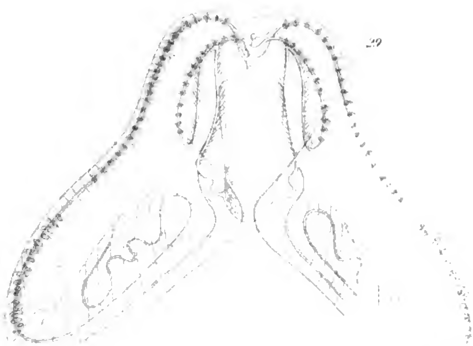
PLATE 8



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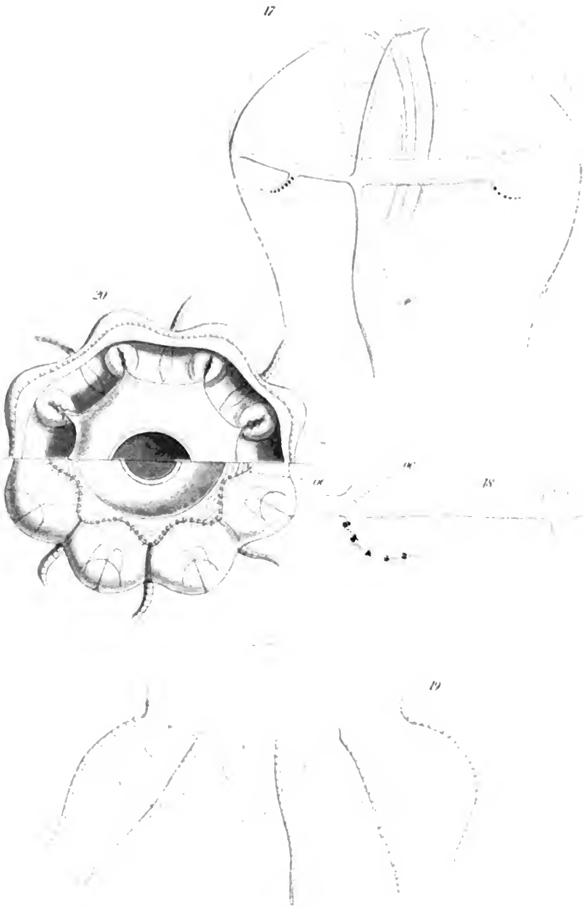

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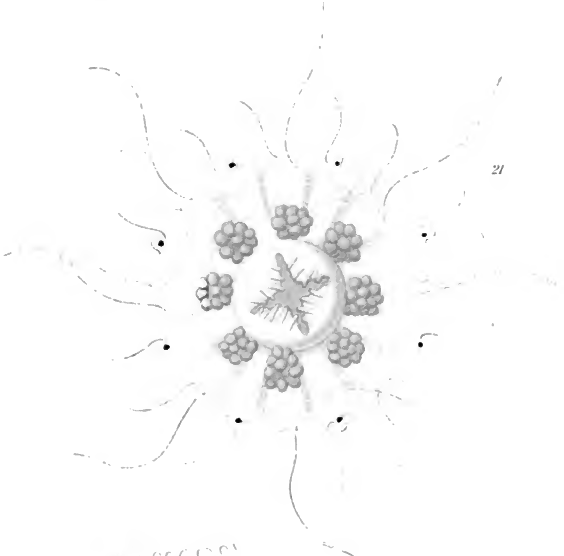

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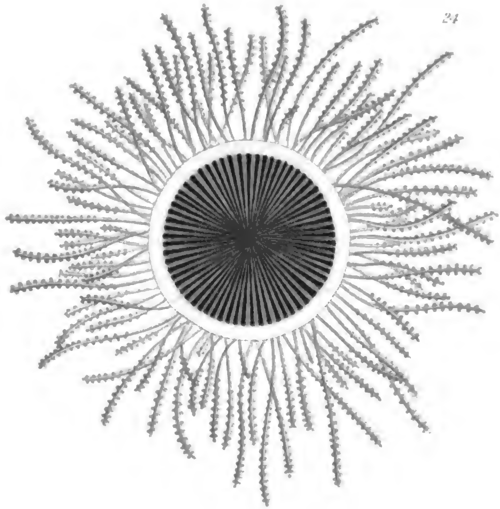

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PLATE 8

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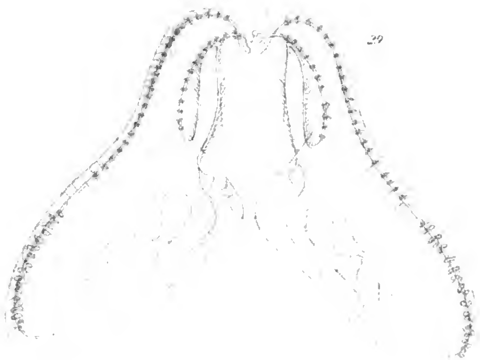
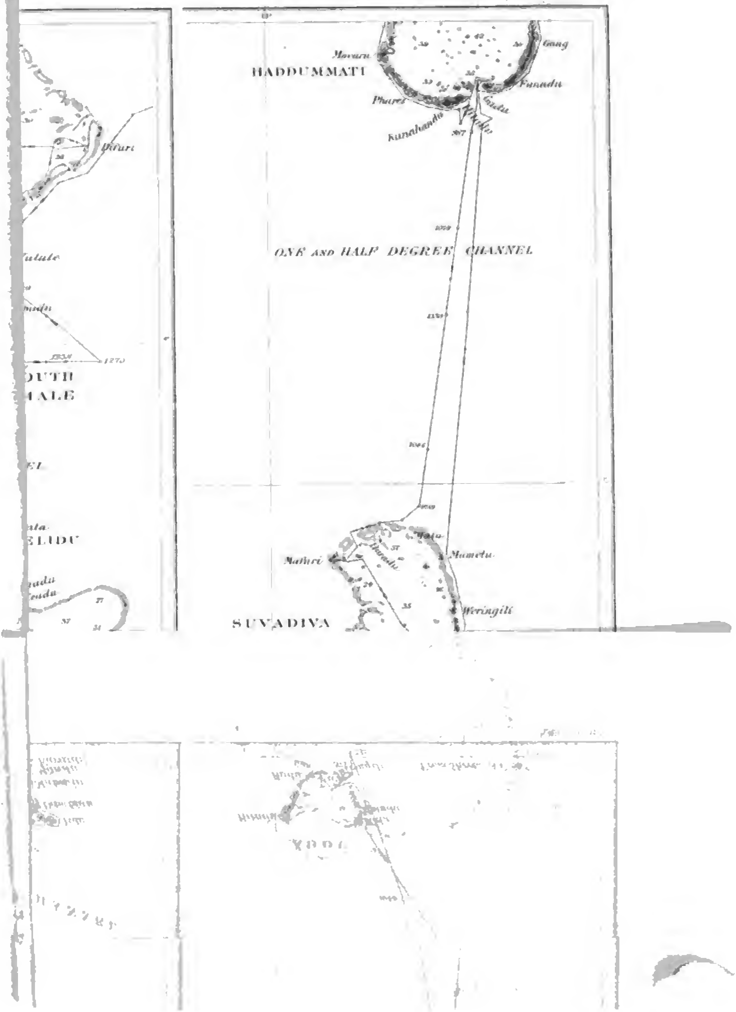


SOUTHERN MALDIVES



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